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Geographical distribution of dry bulk tramp ships: determining probability of employment

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GEOGRAPHICAL DISTRIBUTION OF DRY BULK TRAMP SHIPS

Determining Probability of Employment

By

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Philippines

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the reward of the degree of

MASTER OF SCIENCE
in
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SHIPPING MANAGEMENT AND LOGISTICS

2020

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature):

(Date): **22/09/2020**

Satya R Sahoo

Supervised by: **Dr. Satya Sahoo**

World Maritime University

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Abstract

Title of Dissertation:

Geographical Distribution of Dry Bulk Tramp Ships : Determining Probability of Employment

Degree:

Master of Science

This dissertation is a study on the geographical distribution of different dry bulk ship segments in tramp trade using actual historical trade data to determine the probability of employment in each geographic zone together with the market assessment of the period.

A brief look is taken at the current state and trends of tramp ship routing and scheduling problems and the solutions and methods applied for optimizing bulk carrier fleet planning with an overview of developed optimization algorithms requiring different approaches and implementations.

The concluding chapters examine the results of the assessment that may provide decision support for shipowners and operators.

KEYWORDS: Dry bulk, tramp shipping, geographical distribution, probability of employment

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List of Abbreviations

ARAG	Amsterdam-Rotterdam-Antwerp-Gent
ECCA	East Coast Central America
ECSA	East Coast South America
NCSA	North Coast South America
TSRSP	Tramp Ship Routing and Scheduling Problem
UNCTAD	United Nations Conference on Trade and Development
VLOC	Very Large Ore Carrier
WCCA	West Coast Central America
WCSA	West Coast South America

Chapter 1. Introduction

In general, commercial cargo shipping is differentiated into three basic modes: industrial shipping, liner shipping, and tramp shipping. Industrial shipping is that in which the operator owns both the ships and the cargoes in an attempt to minimize overall costs. Liner shipping is comparable to a bus service with static schedule planning due to its operating with predetermined itineraries and is mainly characterized by container ships. Tramp shipping can be compared to more dynamic taxicabs that follow cargo where available and is most profitable—not according to fixed routes and schedules. Both industrial and tramp shipping is mainly characterized by tankers and dry bulk carriers (Christiansen, Fagerholt, & Nygreen et al., 2007; Vilhelmsen et al., 2013). Contrary to liner shipping, where port choice is strongly related to its geographical location, routing patterns for tramp shipping is challenging to plan as origin and destination ports are irregular and may change based on shippers' demands. Geographical distribution of dry bulk tramp ships is therefore an interesting topic for research. This study aims to identify each zone according to its load and discharge activity percentage and determine a bulk tramp ship's employment probability when in that zone.

The United Nations Conference on Trade and Development (UNCTAD) in its Review of Maritime Transport (2019) reports an all-time high total volume of 11 billion tons traded worldwide through commercial cargo shipping, representing roughly 90% of total world trade. Among those cargoes, 3,194 million tons were crude oil, refined petroleum products, gas, and chemicals; 3,210 million tons were main bulk cargoes that include iron ore, grain coal, bauxite/alumina, and phosphate; and 4,601 million tons were minor bulk cargoes in containerized trade and residual general cargo. Increased industrialization and liberalization of national economies, free trade, and growing demand for consumer products have caused the general trend of the increasing volume of total worldwide trade, supported by advancements in technology, making shipping an increasingly efficient transportation mode. The total world fleet capacity was 1,976.5 million tons, with bulk carriers representing nearly half of the total capacity at 42.6 percent or 842.4 million tons (UNCTAD, 2019). The International Convention for the Safety of Life at Sea (SOLAS) defined a bulk carrier as 'a ship constructed with a single deck, top-side tanks, and hopper side tanks in cargo spaces and intended to carry dry cargo in bulk primarily; an ore carrier; or a combination carrier.' The worldwide dry bulk carrier fleet is subdivided into vessel size categories that determine their volume capacity, trade route, and geographical port restriction. Bigger cargo parcels use larger bulk carriers to achieve economies of scale (Li, Zhen & Xu, 2009); smaller bulk carriers offer more flexibility and access to more ports globally. These categories are presented in Table 1.

Table 1. Dry Bulk Vessel Size Categories

Description	DWT (tonnes)	Cargoes
Minibulk	< 10 000	Grain, Coal, Steels, Cement, Potash, Phosphate rock, Rice, Sugar, Gypsum, Forest products, Scrap, Sulphur, Nickel ore, Salt
Handysize	20 000 < 40 000	
Handymax	40 000 < 50 000	
Supramax	50 000 < 60 000	
Panamax	60 000 < 80 000	Iron ore, Coal, Grain, Bauxite
Post Panamax	< 125 000	
Capesize	125 000 < 220 000	Iron ore, Coal
Very Large Ore Carrier (VLOC)	> 220 000	

Note: Dry bulk vessel size categories by cargo-carrying capacity adapted from “Ship Construction” by Eyres (2006). Cargo information adapted from AXSMarine (2020).

Chapter 1.1 Dry Bulk and Tramp Shipping

Dry bulk shipping is a business that spans across the globe but with only a number of major trade routes between exporting and importing zones. The three major dry bulk commodities are iron ore, coal (steam coal and coking coal), and grains. Minor bulks include agricultural and forest products, cement, sugar, and steels. Coal is primarily imported from Australia and Canada for export to the Far East and Europe, whereas Australia and Brazil mainly ship iron ore to China, Japan, and Europe. The US Gulf, Brazil, and Argentina export Grain to Europe and the Far East. Conversely, minor commodities and general cargo present many other routes for import and export (UNCTAD, 2019). Dry bulk vessels are then employed for tramp service either in the spot market where the contracts are for one or more voyages than can last up to a few months or in the period time charter market where contracts can range from several months to several years. In general, spot rates tend to be higher than time charter rates. While strong spot rates can usually generate higher earnings in profitable markets, it does not provide a steadier income stream over a more extended period, nor does it reduce short-term market volatility as time charter does (Christiansen, Fagerholt & Ronen, 2004). It then depends on the strategy and market trend interpretation of the shipowners and operators to mix spot and time charter employment to maximize profitability.

Shipping cycles present in the shipping industry are also to be taken into account. Long term cycles, as is common to many other industries and the economy as a whole, are those sustained or expected to be sustained over the long term driven by technical, economic, or regional changes that are used to determine the underlying trends in short-term cycles (Mills, 2002). The short term or the business cycle in shipping is categorized by Stopford (2009) in four steps: trough, recovery, peak, and collapse. The first step, "trough," is characterized by an excess of capacity, ships accumulating at ports, and low freight costs to about breakeven of operating costs. The second step, "recovery," is characterized by an equilibrium wherein supply and demand go hand in hand, and freight rates start to increase, eventually surpassing operating costs. The third step, "peak," is characterized by the business operating at peak profit as freight rate is highest, and almost all of the ships are in operation. The fourth stage, "collapse," occurs when the supply exceeds demand; thus, the freight rates begin to decrease, and ships accumulate at ports. Demand and supply play an important role in deciding the direction to take in the dry bulk shipping cycle as freight rates are driven by it. Stopford (2009) continued to discuss that the development of demand is affected by the world economy, seaborne commodity trades, average haul and ton-miles, random shocks, and transport costs, while supply is affected by the global fleet's size, availability, and freight revenue. Also, dry bulk shipping is affected by seasonality that may come in the form of weather disruptions, demand cycle, harvest and production cycle, for main bulks such as iron ore, coal, grain, and for other minor bulk commodities (Kavussanos & Alizadeh , 2001). Understanding the shipping cycle—as well as the trade development cycle due to shipping being a derived demand from trade—is a critical step in devising the most efficient schedule to utilize ships in a tramping fleet (Stopford, 2009).

Chapter 1.2 Research Contribution and Interest

For tramp operators, the TSRSP is practically determining which spot cargoes to transport, assigning all contract cargoes and selected spot cargoes to specific ships, and at the same time finding the sequence and timing of port calls for all ships (Vilhelmsen, Larsen, & Lusby, 2017). Thus, creating the need for specific models and solution methods to optimize tramp ship routing and scheduling. Tramp Ship Routing and Scheduling Problem (TSRSP) for maritime transportation are highly similar to the well-researched Vehicle Routing Problem (VRP) for land transportation, with the most similar being the vehicle routing problem with pickup and deliveries and time windows (VRPPDTW) by Desaulniers et al. (2002). However, one significant difference is the high uncertainty in scheduling and planning ships due to its operating 24 hours a day and under all weather conditions (Rodrigue et al., 2016). Christiansen, Fagerholt, & Ronen (2004) compared and contrasted the operational characteristics of the different freight transportation modes, as shown in Table 2.

This paper aims to provide decision support for bulk carrier shipowners and operators by presenting an overview of dry bulk tramp ships' geographical distribution according to its load and discharge activity by size segment (minibulk, handysize, handymax, supramax, Panamax, Post Panamax, Capesize, VLOC) from 2013 to 2018; allowing for better understanding of actual data on the geographical patterns of dry bulk trade for that period.

The probability of employment per geographic trade zone presented in this paper is developed from actual trade data and will be of particular interest to shipowners and operators in optimizing ship routing and scheduling. Data presented can also help researchers develop solutions and model processes based on actual trade data for TSRSP.

Table 2. Characteristics comparison of different freight transport modes

Operational Characteristic	Ship	Aircraft	Truck	Train
Fleet Variety physical and economic	Large	Small	Small	Small
Power unit as an integral part of the transportation unit	Yes	Yes	Often	No
Transportation unit size	Fixed	Fixed	Usually fixed	Variable
Operating around the clock	Usually	Seldom	Seldom	Usually
Trip or voyage length	Days or weeks	Hours or days	Hour or days	Days
Operational uncertainty	Larger	Larger	Smaller	Smaller
Right of way	Shared	Shared	Shared	Dedicated
Pays port fees	Yes	Yes	No	No
Route tolls	Possible	None	Possible	Possible
Destination change while underway	Possible	No	No	No
Port period spans multiple operational time windows	Yes	No	No	No
Vessel-port compatibility depends on load weight	Yes	Seldom	No	No
Multiple products shipped together	Yes	No	Yes	Yes
Returns to origin	No	No	Yes	No

Note: Information is retrieved from Ship Routing and Scheduling: Status and Perspectives by Christiansen, Fagerholt, & Ronen, 2004.

Chapter 1.3 Structure of the Thesis

This research work is divided into five chapters.

Chapter one is divided into three main parts. First is the introduction to world trade and the different commercial cargo shipping modes with particular emphasis on tramp shipping. Second is a presentation to tramp ship routing and scheduling problems for fleet optimization. Last is about the research contribution of this thesis to shipowners and operators.

The second chapter contains a summary of the current state and trends in tramp ship routing and scheduling problems and the solutions and methods applied for optimizing bulk carrier fleet planning with an overview of developed optimization algorithms requiring different approaches and implementations. Moreover, it states the gap in the research work that this study intends to cover.

The third chapter explains the data set used in this study and the process to which said data is analyzed.

The fourth chapter discusses the geographical distribution of the different dry bulk ship segments in tramp trade using actual historical trade data, analyzing the probability of employment for bulk tramp ships in each geographic zone, as well as its intended discharge zones.

The fifth and final chapter of this thesis is the concluding chapter that gives a summary of the objective of the thesis and its outcome while highlighting the difficulties and limitations of the research work performed.

Chapter 2. Literature Review

Chapter 2.1. Background

The importance of tramp shipping in world trade is evident as bulk cargoes are primarily transported by bulk carriers in tramp service. As such, tramp shipping companies target planned routes and schedules to achieve a competitive advantage. However, as mentioned in the previous chapter, tramp shipping follows cargo where available and is most profitable and not according to fixed routes and schedules, thus presents an optimization problem for route planners and operators. Pache, Kastner & Jahn (2019) reported and compared existing solutions to TSRSP that include understanding its complexity as an optimization problem as presented by Christiansen et al. (2013) and provided an overview of the current state of developed optimization algorithms requiring different approaches and implementations.

Chapter 2.2. Current State and Trends in Tramp Ship Routing and Scheduling

One solution to TSRSP by Hemmati et al. (2014) is presenting a wide range of benchmark instances and benchmark generator to provide test instances representing realistic planning problems through exact and heuristic methods. This solution serves as a basis for developing better solution algorithms but is restricted to calculating ships in a heterogeneous fleet that sail with a fixed speed with spot charter options and applies to short and long voyage problems with full or mixed loads. The solution for instances on a small scale used a commercial mixed-integer programming solver and for instances on a large scale, a large adaptive neighborhood search (ALNS) heuristic was used.

Solutions to TSRSP with variable speed include increasing the overall profit of a tramp fleet through speed optimization to reduce fuel consumption and emissions with Fagerholt & Ronen (2013) proving its benefits. Castillo-Villar et al. (2014) based their model on the work of Gatica & Miranda (2011) that assumed that spot and contract cargoes as indistinct because all cargo at the beginning of each planning period is known. Castillo-Villar et al. (2014) proposed a heuristic based on a variable search algorithm with fixed values for speed and time windows in the test instances and the results compared to CPLEX generated solutions. Wen et al. (2016), on the other hand, considered a heterogeneous fleet of ships in ballast or full loaded with variable speed—neglecting operating costs other than fuel consumption. Wen et al. (2016) showed that allowing speed variation could increase the profit of a tramp fleet. Yu et al. (2017a) proposed a fast elitist non-dominated sorting genetic algorithm (NSGAII) to optimize the sailing speed under two aspects: minimize carrier operation costs and maximize cargo owner satisfaction. Assuming that shipping costs are only speed-dependent, the total cost is reduced to fuel consumption cost, which can be lowered by slow-steaming. Fuzzy time windows are used to measure the shipper's service satisfaction, assuming that satisfaction is decreased when the estimated time of delivery is not met. However, as the ship routes and transported cargoes are known beforehand and spot and contract cargoes are indistinct, Yu et al. is not taking into account a common TSRSP. Even then, Yu et al. confirms in their result the correlation between lowering operating costs for the shipowner and efficient delivery for the charterer.

For TSRSP with environmental constraints, Wang et al. (2019) investigated the effects of two measures for CO2 reduction on operational decisions in a TSRSP in line with the International Maritime Organization (IMO) 's goal to reduce greenhouse gas emissions. The authors used a mathematical model to evaluate a bunker levy's impacts on average travel speed and its emissions to the amount of cargo transported. However, as the authors focused on operational planning, they have not found out about market-based CO2 reduction measures on strategic planning. They concluded that an increase in levies or fuel prices or the combined increase in both decreases the earnings, the average sailing speed, the quantity of transported cargoes, and the CO2 emissions.

For TSRSP with split-loads and flexible size loads, Fagerholt et al. (2013) used a Tabu search heuristic and looked into project shipping as a sub-segment of tramp shipping, with unique cargoes that require more stringent requirements and constraints regarding onboard stowage such as cargo-coupling where cargoes can only be shipped together. Stålhane, Andersson & Christiansen (2015) also investigated project shipping with the same restriction but included synchronization constraints; these are restrictions on the different delivery schedule of each part of the cargo-set. The authors proved that a bench-and-price algorithm reduced the calculation time and concluded project shipping with instances in the large-scale are more straightforward to plan than tramp shipping where ship capability restrictions are stricter, resulting in less feasible cargoes.

The first to introduce Vendor Managed Inventory (VMI) to a TSRSP are Stålhane, Andersson, Christiansen, & Fagerholt (2014). The authors replaced the Contract of Affreightment (CoA) with VMI because it provides the opportunity to improve the whole supply chain by allowing for increased flexibility in the amount of cargo and delivery schedules. The CoA only defines the amount of cargo transported in a fixed schedule of port calls and the cost per ton of cargo but not the total cargo quantity onboard the ship. The authors solved the basic TSRSP with VMI by developing a hybrid approach of generating schedules dynamically using Priori path generation of all feasible routes and a branch-and-price network. The results are compared with exact route generation instead of the proposed heuristic route generation. Stålhane et al. concluded that replacing the CoA with VMI, although unrealistic, if applied to the tramp market, will lead to earnings for charterers and tramp ship operators through increased profit, particularly if the market is low and select cargoes are available for spot charter. Hemmati et al. (2015) then developed a method to solve realistically scaled instances, following up on the preliminary work of Stålhane et al. (2014) by introducing a two-phase heuristic that first converts the inventories into cargoes and solves TSRSP using an ALNS method. Computing time is reduced by clustering feasible combinations using a k-means algorithm and then solved using the ALNS algorithm. The second phase is analyzing the solution using the described heuristic. Hemmati et al. (2015) concluded that the fleet composition, the number of spot cargoes available, and the amount of VMI-converted contracts directly affect VMI's benefits.

Vilhelmsen et al. (2014) looked into the effects of bunker planning in the TSRSP to be able to increase profit by considering spot and contract cargo with the following restrictions: ships can sail either in ballast or fully laden condition, and each ship maintains sailing at the most economical speed. The authors tested instances with variable spot cargo percentage and bunker rates and discovered that instances with more spot cargoes are most affected by bunker price fluctuations. The approach Meng, Wang & Lee (2015) took is similar to Vilhelmsen et al. (2014) but with the main difference in assuming that travel speed is fixed with no detours for bunkering—ships can only bunker in loading and unloading ports. Meng, Wang & Lee's (2015) objective in their solution to TSRSP is to determine how to maximize profit by identifying the amount of fuel by using a branch-and-price method.

Authors such as Guan et al. (2017) and Yu, Wang et al. (2017) included uncertainties such as weather conditions, cargo output, or berthing delays. First, the authors considered the seasonality of demand and its corresponding effect on freight rates, influencing the revenues of tramp ships. Second, weather conditions are statistically represented in the test instance. The authors then applied a genetic algorithm for various test instances with both static and uncertain cargo demand when generating voyage schedules but these instances cannot present an exact solution as it lacks comparison to actual trade data.

Chapter 2.3. Verification of Research Gaps

An overview of the reviewed literature with each of its test instance parameters is listed in Table 3. After reporting and comparing the developed solutions to TSRSP, it is observed that different problem characteristics have categorized a wide range of findings. However, few publications include the effect on revenue in tramp shipping by the geographical fluctuations of demand in dry bulk trade. A better understanding of actual data on the geographical patterns of dry bulk trade is required to make more effective ship allocation decisions to regions or charter contracts. The current trend on the TSRSP is applying artificial data that is generated at random due to the lack of real-life data (Pache, Kastner & Jahn, 2019). As such, it presents the risk of developing unrealistic solutions for actual problems. The same can be said in the simplification of mathematical models, as Fagerholt & Ronen (2013) stated. Psaraftis (2019) recommends shifting the focus from developing solution methods to modeling processes of the real-world problem. Accordingly, this dissertation will provide actual historical trade data of different bulk carrier sizes in different trade zones from 2013 to 2018 that can be used to provide decision support for shipowners and operators.

Table 3. Test instance parameters by reviewed literature

Publication	Planning Horizon in Days	Number of Ships	Number of Cargoes
Wang et al. (2019)	not fixed	6 to 20	25 to 50
Zhao and Yang (2018)	365	6	undefined
Guan et al. (2017)	300 to 360	17	94
Vilhelmsen, Lusby, and Larsen (2016)	90 to 150	10 to 32	4 to 13
Wen et al. (2017)	not fixed	3	6 to 31
Yu et al. (2017)	not fixed	1	4
Yu, Wang, and Wang (2017)	365	5 to 25	500
Wen et al. (2015)	30 to 90	20 or 32	40 to 160
Armas et al. (2015)	not fixed	4 to 7	30 to 50
Hemmati et al. (2015)	not fixed	4 to 8	10 to 30
Meng, Wang, and Lee (2015)	not fixed	20 or 40	20 to 60
Stålhane, Andersson, and Christiansen (2015)	not fixed	3 or 4	10 to 32
Stålhane et al. (2014)	not fixed	4	6 to 15
Christiansen and Fagerholt (2014)	not fixed	undefined	undefined
Hemmati et al. (2014)	not fixed	3 to 50	7 to 130
Vilhemsen, Lusby and Larsen (2014)	30 to 60	7	30 to 60
Castillo-Villar et al. (2014)	not fixed	4 to 7	30 to 50
Fagerholt et al. (2013)	not fixed	2 to 8	6 to 63

Note: Test parameters are from existing methods and solutions to TSRSP from reviewed literature.

Chapter 3. Methodology

In this study, data is based on actual trade recorded in each geographic zone for the period of 2013 - 2018 retrieved from AXSMarine Trade Flows—an online database established on a proprietary network that can generate reports containing specific or average voyage durations by route, commodity flows, and ship trading patterns between zones, countries, ports, or berths. It is embedded with regularly updated AIS feeds for its ships, ports, and fixtures, defining ports, berths, anchorages, and sailing routes (Table 4).

Table 4. Data set retrieved from AXSMarine Trade Flows

Vessel Category	Condition	Range	Data Types	
Minisize	Laden	2013 - 2018	Vessel name	Disch Year
Handysize	Ballast		DWT	Disch Month
Handymax			Vessel draft	Disch Zone
Supramax			Load Year	Disch Country
Panamax			Load Month	Disch Port
Post Panamax			Load Zone	Commodity
Capesize			Load Country	Charterer
VLOC			Load Port	Load condition

Note: Access to data in AXSMarine Trade Flows is provided by the World Maritime University for research purposes only.

To determine the probability of employment of a bulk carrier ship in a geographic zone, the researcher will perform the following:

1. Organize the data retrieved according to vessel category.
2. Identify geographic zones with recorded load and discharge activity in the research period.
3. Identify activity distribution among zones by calculating its activity percentage (loading and discharging).
4. Sort geographic zones by order of highest to lowest activity.
5. Calculate the probability of employment for a dry bulk tramp ship in the zone with the highest activity percentage.

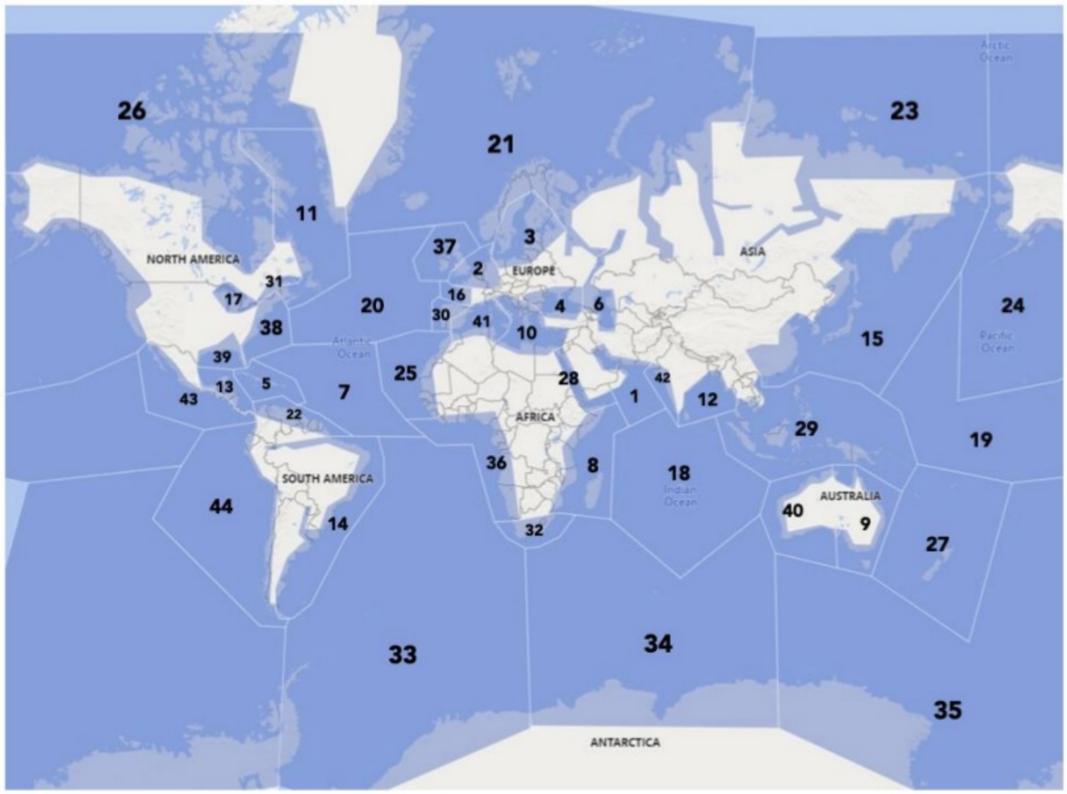
The probability of employment in a geographical zone is represented mathematically using the formula:

$$Probability\ of\ employment\ (zone) = \frac{Number\ of\ ships\ loaded\ (zone)}{Total\ number\ of\ ships\ (zone)}$$

For the purpose of this study, a 50% probability of employment signifies a balanced market where ship supply meets transport demand. An increase in employment probability percentage means there is an increase in transport demand with lesser ship supply that may trigger an increase in freight rates, among other factors. Inversely, a decrease in employment probability percentage means there is a decrease in transport demand with more ship supply that may trigger a decrease in freight rates, among other factors.

The three geographical zones with the highest load and discharge percentage for each segment and the corresponding employment probability in each will be discussed in the succeeding chapter.

Figure 1. Geographic zones according to AXSMarine Trade Flows



1. Arabian Gulf
2. Antwerp Rotterdam Amsterdam Ghent
3. Baltic
4. Black Sea
5. Caribbean
6. Caspian Sea
7. Central Atlantic
8. East Africa
9. East Australia
10. East Mediterranean
11. East Coast Canada
12. East Coast India
13. East Coast Central America
14. East Coast South America
15. Far East
16. French Atlantic
17. Great Lakes
18. Indian Ocean
19. Mid Pacific
20. Mid North Atlantic
21. North Continent
22. North Coast South America
23. North East Passage
24. North Pacific
25. Northwest Africa
26. Northwest Passage
27. New Zealand
28. Red Sea
29. Southeast Asia
30. Spain Atlantic
31. Saint Lawrence
32. South Africa
33. South Atlantic
34. South Indian Ocean
35. South Pacific
36. Southwest Africa
37. United Kingdom - Ireland
38. US East Coast
39. US Gulf
40. West Australia
41. West Mediterranean
42. West Coast India
43. West Coast Central America
44. West Coast South America

Note: Geographic zone map is adapted from AXSMarine Trade Flows through the World Maritime University

Chapter 4. Findings and Discussion

Chapter 4.1. VLOC Geographic Distribution

Clarkson Research (2013)'s market assessment at the beginning of the research period 2013 has the average earnings in all bulk carrier sectors in decline due to continued oversupply—63% lower than the ten-year historical average of 21,179 USD per day—at 7,731 USD, encouraging owners to operate at slower speeds to reduce bunker costs. For most of the year, average earnings in all bulker sectors remained below or close to breakeven operating expenses. Despite the surge in Capesize newbuilding deliveries, the Capesize market has benefited the highest spot earning since 2011 due to Chinese iron ore import growth, particularly during the fourth quarter of 2013, where Capesize earnings exceeded 40,000 USD per day for two short-lived periods. A total of 205 Capesize vessels were contracted for newbuilding, which is significantly above the ten year average of 150 contracts per annum. This expansion in the orderbook was motivated by low newbuilding prices and periods of improved freight rates.

Table 5 displays the loading and discharging percentages for each geographic zone that VLOC vessels have performed cargo operations from 2013 through 2018. The three zones with the highest loading activity are as follows: East Coast South America - ECSA (49.06%), West Australia (46.94%), and South Africa (1.75%). As for discharge activity, the Far East leads by as much as 86.37%, followed by Southeast Asia with only 7.07% and the Persian gulf with 2.61%.

VLOC has a cargo-carrying capacity of not less than 220,000 to as high as 400,000 deadweight tons with dimensions extending up to 360 meters length, 65 meters breadth, and 24 meters draught; and is thus able to carry their cargo significantly cheaper per ton-mile than smaller Capesize vessels by achieving economies of scale. VLOC mainly transports iron ore and coal in extended ocean passages to world ports with adequate infrastructure to accommodate its size. Valemax ships are currently the largest VLOC's owned and chartered by Vale S.A.—a mining company based in Brazil that exports iron ore to European and Asian ports.

Table 5. Geographical distribution of trade activity for VLOC.

	LOADING
Zone	%
ECSA	**49.059%**
West Australia	**46.940%**
South Africa	**1.747%**
Southeast Asia	0.827%
Far East	0.743%
Saint Lawrence	0.599%
Black Sea	0.034%
Persian Gulf	0.034%
Caribbean	0.017%
	100%

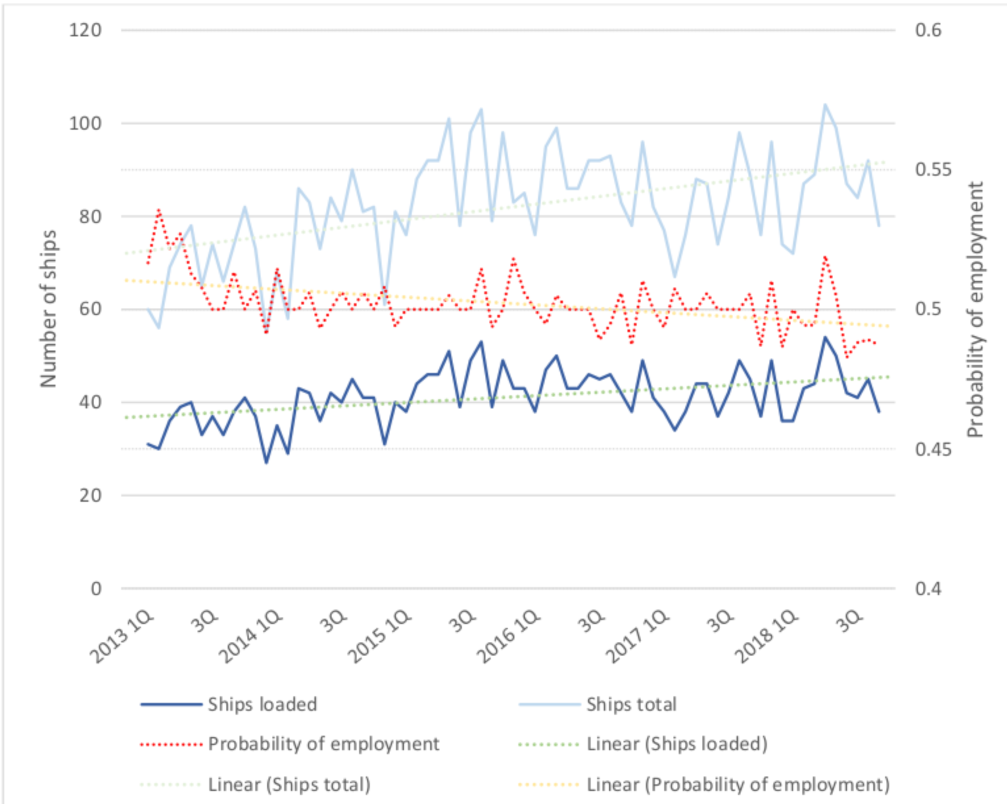
	DISCHARGE
Zone	%
Far East	**86.367%**
Southeast Asia	**7.074%**
Persian Gulf	**2.608%**
ARAG	2.085%
East Mediterranean	1.030%
ECSA	0.270%
West Australia	0.194%
Spain Atlantic	0.177%
Indian Ocean	0.068%
West Mediterranean	0.068%
South Africa	0.034%
Black Sea	0.008%
ECCA	0.008%
East Coast India	0.008%
	100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

In 2018, Australia and Brazil accounted for a combined 83% of iron ore exports. On the other hand, demand for iron ore came primarily from China, which was estimated to have imported 1.4 billion tons, or 43.5% of global maritime major bulk trade, while the entirety of Europe accounts for only seven percent of iron ore import led by the ARAG zone with 2.09% discharge percentage. Australia accounts for more than half of the total volume of coal exported in 2018, followed by Brazil (26%) and South Africa (4%). Major coal importers based on world market shares are China (18%), Japan (8%), and India (7%)(UNCTAD, 2019). This explains the considerable gap in loading and discharge percentage of the geographical zones for the VLOC segment (Table 5). South Africa accounts for four percent of iron ore exports, which explains its zone ranking third in employment probability with 1.75% (Table 5; UNCTAD, 2019).

ECSA loaded 49.06% of the total number of VLOC ships worldwide between 2013 and 2018, and Brazil is the only loading country to receive VLOC's for that zone. Brazil has several different ports, such as Acu, Guaiba, Itaguai, Itaqui, Santos, and Tubarao, to name a few. Commodities are coal, steam coal, iron ore, iron ore fines, iron ore pellets, and corn. The primary discharge zone is the Far East, with about 75% of the total commodity loaded in ECSA discharged there, while Southeast Asia has imported around 15%, the Persian Gulf 5%, and the ARAG 3%. It can be observed that the ship supply trend from 2013 to 2018 for that zone is increasing more rapidly than the number of ships chartered and loaded, resulting in a decrease in employment probability. And that the demand for iron ore exhibits an increase during the second half of each year. Despite it, the average probability of employment is 50% (Figure 2).

Figure 2. Probability of employment in East Coast South America (VLOC)



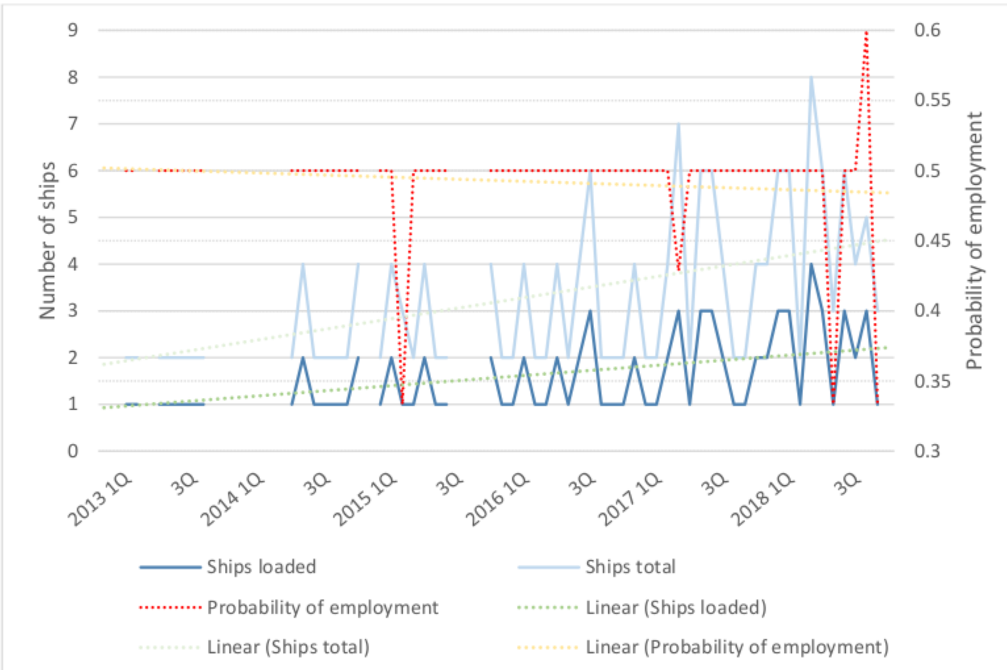
Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

The loading ports in the West Australia geographic zone are Cape Lambert, Cape Preston, Dampier, Port Hedland, and Port Walcott with cargoes of iron ore bound for the Far East, Southeast Asia, and West Australia. There is a more considerable increase in ship supply than transport demand in the zone; this resulted in a decreasing trend in employment probability. The total number of ships multiplied by more than double from the beginning to the end of the research period, with an average employment probability of 50% (Figure 3).

Figure 3. Probability of employment in West Australia (VLOC)

Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 4. Probability of employment in South Africa (VLOC)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

South Africa ranked third in loading percentage, but that is coming from loading only around 100 VLOC's in six years with a total number of ships in the zone not exceeding 200 for that period (Figure 4). In 2017, BIMCO analyzed and found out that the 51 VLOC ships in the fleet have an average age of 23.8 years, close to its average demolition age of 24.2 years. Since then, 22 have been scrapped, one is damaged and non-serviceable, and the VLOC fleet is down to a mere 28 ships, eight of which are laid up in Labuan. BIMCO predicts that the VLOC segment might soon be made obsolete (BIMCO, n.d.).

Table 6. Load zone to discharge zone mapping (VLOC)

LOAD ZONE	ECSA		West Australia		South Africa	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	94	3.20%	0	0.00%	1	0.95%
Black Sea	0	0.00%	0	0.00%	0	0.00%
WCCA	0	0.00%	0	0.00%	0	0.00%
East Coast India	0	0.00%	0	0.00%	0	0.00%
ECSA	6	0.20%	0	0.00%	1	0.95%
East Mediterranean	55	1.87%	0	0.00%	2	1.90%
Far East	2184	74.29%	2777	99.43%	100	95.24%
Indian Ocean	2	0.07%	0	0.00%	0	0.00%
Persian Gulf	157	5.34%	0	0.00%	0	0.00%
South Africa	0	0.00%	0	0.00%	0	0.00%
Southeast Asia	423	14.39%	1	0.04%	0	0.00%
Spain Atlantic	11	0.37%	0	0.00%	0	0.00%
West Australia	1	0.03%	9	0.32%	1	0.95%
West Mediterranean	4	0.14%	0	0.00%	0	0.00%
Worldwide	3	0.10%	6	0.21%	0	0.00%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

Table 6 displays the load-discharge mapping of VLOC's coming from the top three geographic zones with the highest load percentage, majority of the VLOC's that loaded in the ECSA were bound for the Far East, with less than a quarter of the discharge activity for Southeast Asia and the Persian Gulf. While almost all VLOC's coming from West Australia and South Africa are also bound for the Far East. It can be concluded that laden VLOC voyages are one way trips from load zones of ECSA, West Australia, and South Africa. While return voyages are mostly in ballast condition.

Chapter 4.2. Capesize Geographic Distribution

Capesize vessels are ships with a cargo-carrying capacity of between 125,000 and 220,000 deadweight tons (Eyres, 2006) that cannot pass through the Panama canal when transiting between the Pacific and Atlantic oceans, or the Suez canal when transiting from the Indian Ocean to the Atlantic Ocean. These ships are then required to traverse south of Cape Horn when crossing from the Pacific to Atlantic oceans, and vice versa; and south of Cape of Good Hope when crossing from the Indian Ocean to the Atlantic ocean, or back. Capesize bulk ships commonly carry iron ore, coal, grain, and bauxite. In 2015, Existing oversupply pressures and a contraction in global seaborne dry bulk trade caused a depression in the dry bulk market. Bulker freight rates slumped and average bulk carrier earnings fell by almost a third year-over-year to 7,123 USD per day: the lowest annual average since 1999. The severe pressure on bulker owners throughout 2015 triggered a surge in scrapping, a collapse in ordering and increased lay-up and idling activity. In the same period, seaborne dry bulk trade declined 0.1% to 4.7 billion tons, the first contraction since 2009. The decline was primarily due to a 6% drop in the total seaborne coal trade and the slow pace of trade growth in iron ore. For the Capesize market, the slowdown in the pace of Chinese iron ore import growth contributed to oversupply in the Capesize market, which dampened rates and earnings. The average spot earnings fell 44% year-over-year to 9,060 USD per day, less than half the preceding five year average of 20,103 USD per day (Clarkson Research, 2015).

Table 7 displays the loading and discharging percentages for each geographic zone that Capesize vessels have performed cargo operations from 2013 - 2018. The three zones with the highest employment probability are as follows: West Australia (43.26%), East Australia (13.77%), and East Coast South America (13.00%). As for discharge zones, the Far East receives a massive 79.41% of commodities transported by Capesize vessels, followed by the ARAG zone with 6.29% and West Coast India with 3.24%.

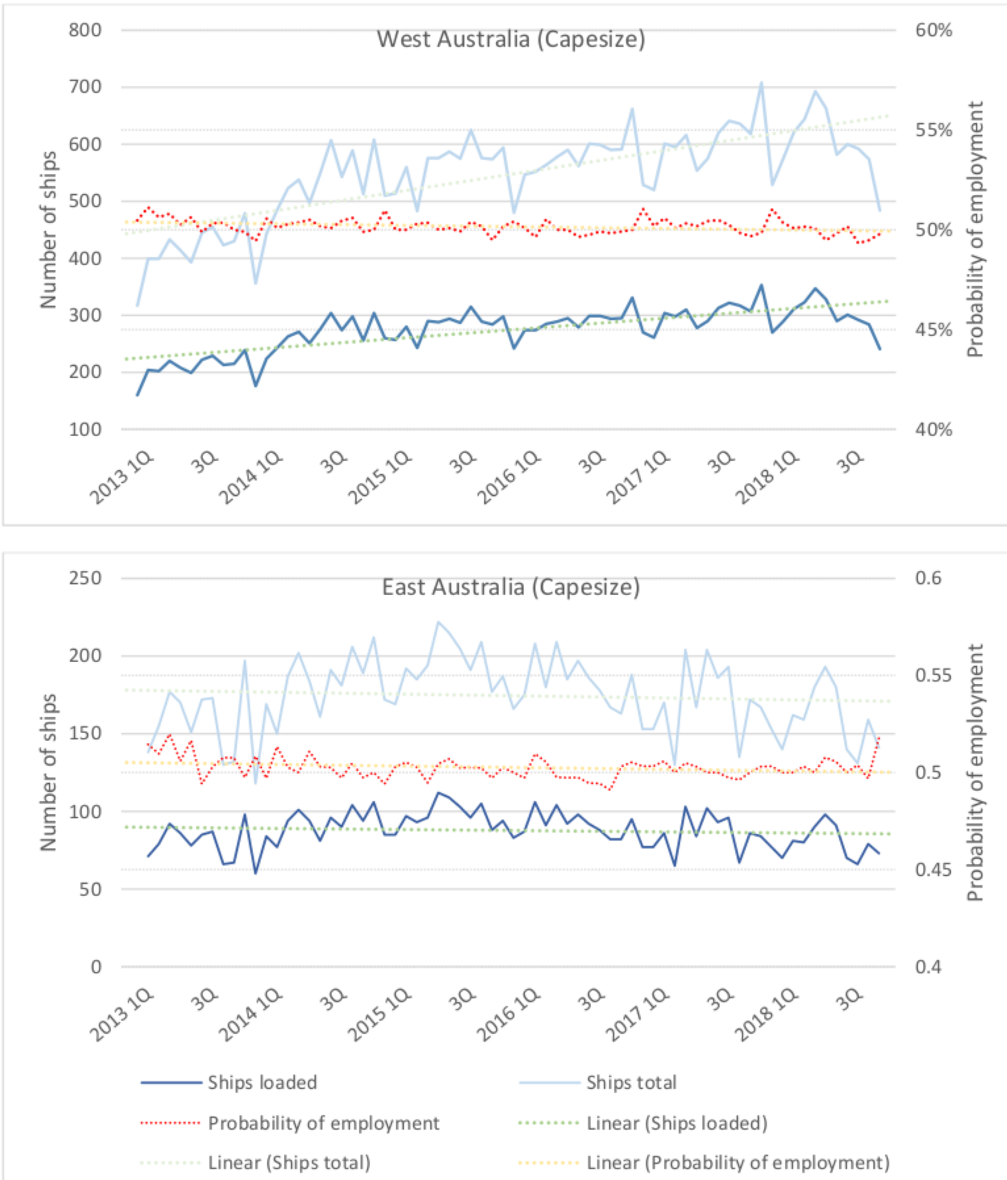
Table 7. Geographical distribution of trade activity for Capesize.

	LOADING		DISCHARGE
Zone	%	Zone	%
West Australia	43.26%	**Far East**	79.41%
East Australia	13.77%	**ARAG**	6.29%
ECSA	13.00%	**West Coast India**	3.24%
South Africa	6.27%	East Mediterranean	2.28%
Southeast Asia	5.55%	EC India	2.02%
NCSA	4.17%	Spain Atlantic	1.27%
Northwest Africa	2.38%	Persian Gulf	1.16%
Saint Lawrence	2.19%	Southeast Asia	0.97%
WCSA	1.99%	Black Sea	0.85%
North Pacific	1.70%	West Mediterranean	0.71%
Others	5.71%	Others	1.80%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

By 2017, shipments from several smaller producers have robustly increased, including India and Iran. Global seaborne coal trade also grew by 5% as Chinese and South Korean imports expanded, European imports stabilized, and demand in emerging Asia multiplied. Guinea China bauxite trade also provided some new opportunities for smaller Capesize vessels (Clarkson Research, 2017). The probability of employment averaged at 49% in the ECSA, one percent lower than the other top-loading zones in the segment. Brazil is the primary exporting country in the zone with iron ore as the main commodity for transport, majority of which is going to China.

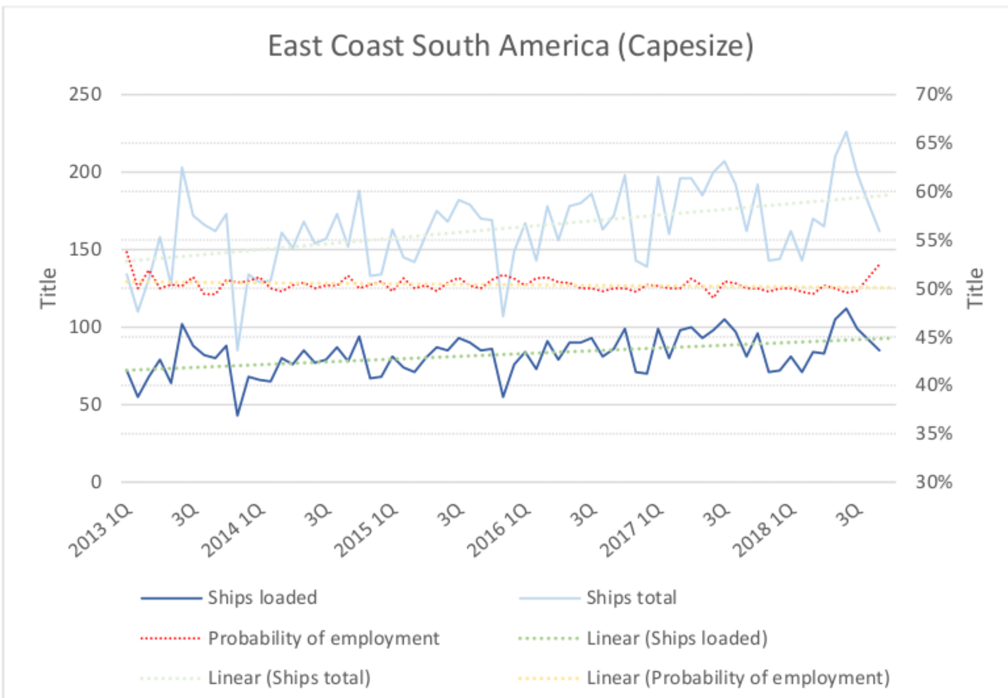
Figure 5. Probability of employment in West and East Australia (Capesize)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 5 compares the loading percentage in the West Australia to that of its Eastern counterpart, the trend is different in that both the total number of ships and the number of ships loaded has generally been increasing in West Australia while it has remained the same in the East Australia albeit with fluctuations. The average employment probability for each is 50%.

Figure 6. Probability of employment in East Coast South America (Capesize)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Table 8. Load zone to discharge zone mapping (Capesize)

LOAD ZONE	**West Australia**		**East Australia**		**ECSA**	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	16	0.08%	390	6.27%	901	15.31%
Baltic	0	0.00%	23	0.37%	1	0.02%
Black Sea	0	0.00%	16	0.26%	67	1.14%
East Africa	0	0.00%	0	0.00%	0	0.00%
East Australia	136	0.69%	6	0.10%	10	0.17%
East Coast Canada	0	0.00%	0	0.00%	0	0.00%
East Coast India	40	0.20%	245	3.94%	18	0.31%
ECSA	1	0.01%	61	0.98%	22	0.37%
East Coast US	0	0.00%	0	0.00%	0	0.00%
East Mediterranean	1	0.01%	59	0.95%	239	4.06%
Far East	19240	98.28%	5046	81.10%	3972	67.49%
French Atlantic	0	0.00%	0	0.00%	0	0.00%
Indian Ocean	0	0.00%	0	0.00%	5	0.08%
North Pacific	0	0.00%	0	0.00%	0	0.00%
NCSA	0	0.00%	0	0.00%	0	0.00%
North Continent	0	0.00%	0	0.00%	1	0.02%
Northwest Africa	0	0.00%	0	0.00%	1	0.02%
Persian Gulf	1	0.01%	0	0.00%	243	4.13%
Red Sea	0	0.00%	0	0.00%	5	0.08%
Saint Lawrence	0	0.00%	0	0.00%	10	0.17%
South Africa	2	0.01%	24	0.39%	5	0.08%
Southeast Asia	104	0.53%	126	2.03%	103	1.75%
Southwest Africa	1	0.01%	1	0.02%	0	0.00%
Spain Atlantic	2	0.01%	41	0.66%	92	1.56%
UK -Ireland	0	0.00%	4	0.06%	30	0.51%
USG	0	0.00%	0	0.00%	1	0.02%
West Australia	10	0.05%	1	0.02%	4	0.07%
WCCA	0	0.00%	63	1.01%	25	0.42%
West Coast India	21	0.11%	73	1.17%	43	0.73%
WCSA	1	0.01%	2	0.03%	2	0.03%
West Mediterranean	0	0.00%	41	0.66%	85	1.44%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

After loading from the geographic zone with the highest activity, the next zone mapped for the Capesize ships are as follows: West Australia to the Far East (98.28%), East Australia to the Far East (81.1%), ECSA to the Far East (67.49%), ECSA to the ARAG (15.3%). Similar to VLOC's, laden voyages from West and East Australia zones bound for the Far East are expected to return in ballast condition, the nearest zone with probability of employment after the Far East is Southeast Asia but with only a recorded load activity of 5.55%.

Chapter 4.3. Post Panamax Geographic Distribution

Post Panamax is the term used to categorize ships that cannot transit the Panama canal due to size restriction. The lock chamber dimensions of the Panama canal are 320.04 m long, 33.53 m wide, and 12.56 m deep, and allows vessels of up to 294.13 m in length, 32.31 m in width and 12.04 m in draught. But this all changed with the opening of the new lane in 2016 that can accommodate larger ships now called New Panamax (Pancanal, n.d.).

Table 9 presents the loading and the discharge percentages of each corresponding geographic zone for this segment during the research period. East Australia, East Coast South America, and Southeast Asia lead by 24.33%, 15.29%, and 14.42%. While the Far East, ARAG, and East Coast India are the leading discharge zones with the Far East ahead by a large margin, receiving almost half of the total number of ships that sailed during the research period. The same can be said for Capesize vessels coming from ECSA to the Far East, it is more likely to return in ballast condition than be employed elsewhere.

Table 9. Geographical distribution of trade activity for Post Panamax

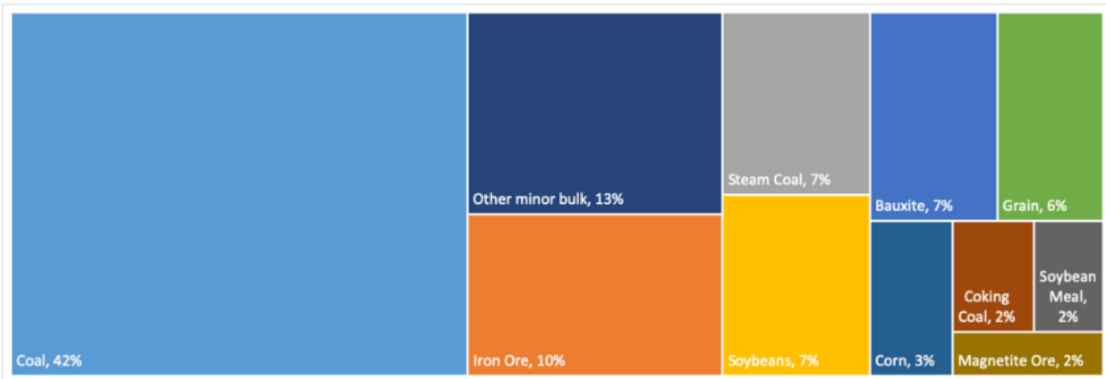
	LOADING		DISCHARGE
Zone	%	Zone	%
East Australia	**24.330%**	**Far East**	**49.490%**
ECSA	**15.286%**	**ARAG**	**9.382%**
Southeast Asia	**13.420%**	**East Coast India**	**5.891%**
Far East	5.793%	Southeast Asia	5.623%
North Pacific	5.422%	West Coast India	4.485%
West Australia	5.077%	Persian Gulf	4.315%
US Gulf	4.799%	ECSA	3.553%
Baltic	4.478%	East Mediterranean	3.096%
South Africa	3.237%	East Australia	2.367%
USEC	3.012%	West Mediterranean	1.734%
Others	15.15%	Others	10.06%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

Figure 7 illustrates the commodity types transported by Post Panamax ships during the research period, with coal taking 42% of the total loading instances. Iron ore takes 10%, and other minor bulk that includes copper, alumina, tapioca, and wood chips take a combined 13%.

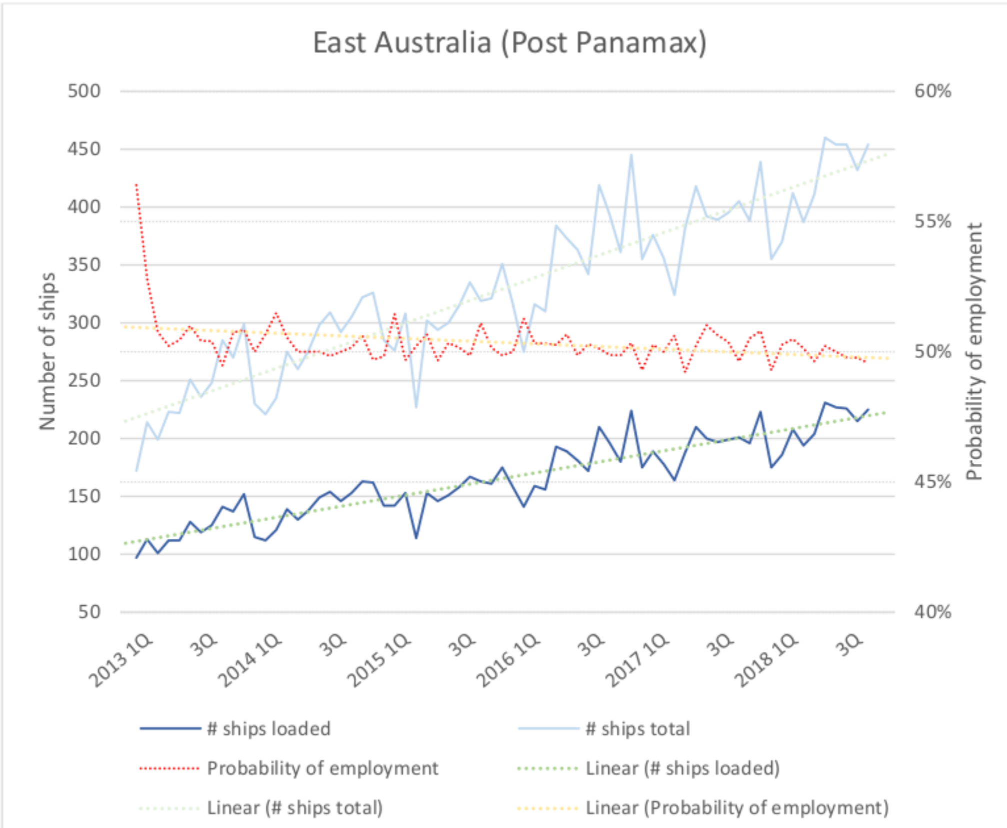
East Australia has led the coal export for the segment during the research period with a steady increase in both demand and supply while maintaining an employment probability rating of 50% (Figure 8). Strong import demand within Asia registered significant growth in the seaborne coal trade from 2013 onwards. The arbitrage between international and domestic coal prices has supported growth in Chinese steam coal imports, making imports more favorable. In India, the expansion of coal-fired power generation capacity has also supported steam coal imports. (Clarkson Research, 2014).

Figure 7. Commodities transported 2013-2018 (Post Panamax)



Note: Commodities transported by Post Panamax vessels with its corresponding percentage ratio during the research period

Figure 8. Probability of employment in East Australia (Post Panamax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Seasonality in the transport demand is highly evident in the ECSA, the reason for which is the type of commodity that the zone is exporting. From the total number of 7,295 loading instance for Post Panamax in the region: 0.12% loaded fertilizer, 0.33% loaded coal, 1.77% loaded steel, 10.13% loaded undefined bulk, 16.30% loaded iron ore, and the remaining 71% loaded agricultural products. The harvest cycle highly motivates transport demand. Probability of employment for ECSA is averaged at 50% for the research period (Figure 9).

Indonesia has led the coal export in the Southeast Asia zone with the Far East as the commodity's destination, particularly China. Other exporters of Indonesian coal are India, Korea, Japan, the Philippines, and Hong Kong. The average probability of employment for the zone is 50% (Figure 10).

Figure 9. Probability of employment in East Coast South America (Post Panamax)

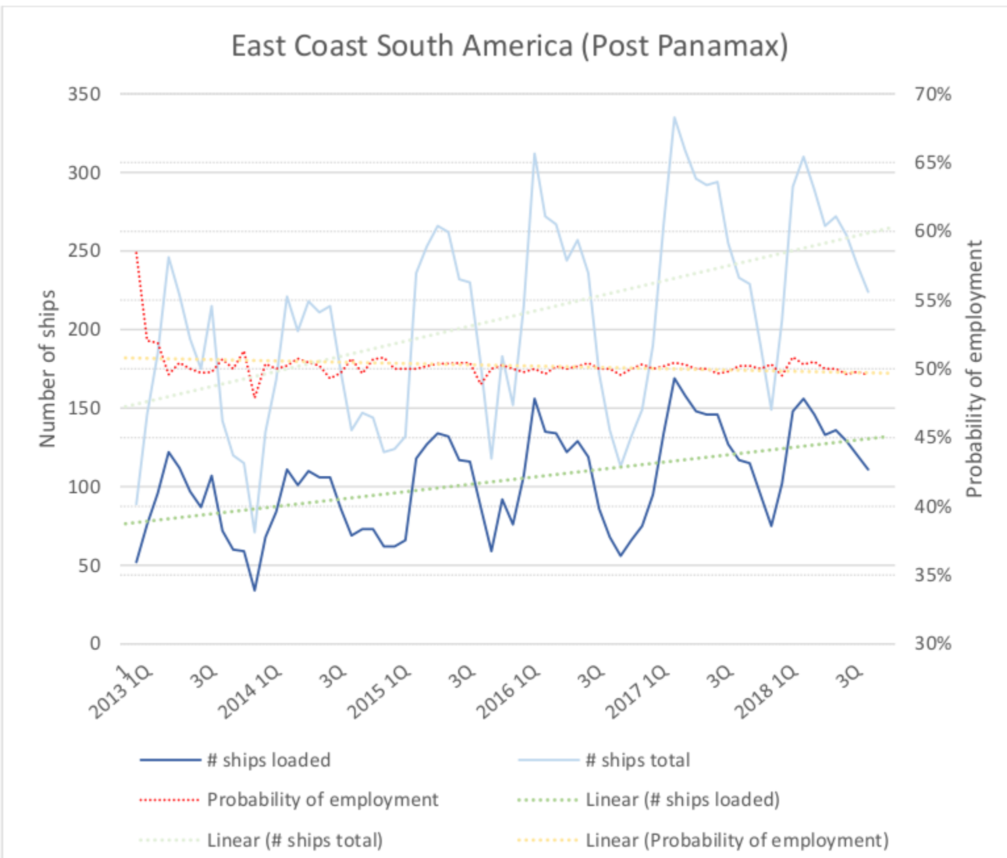
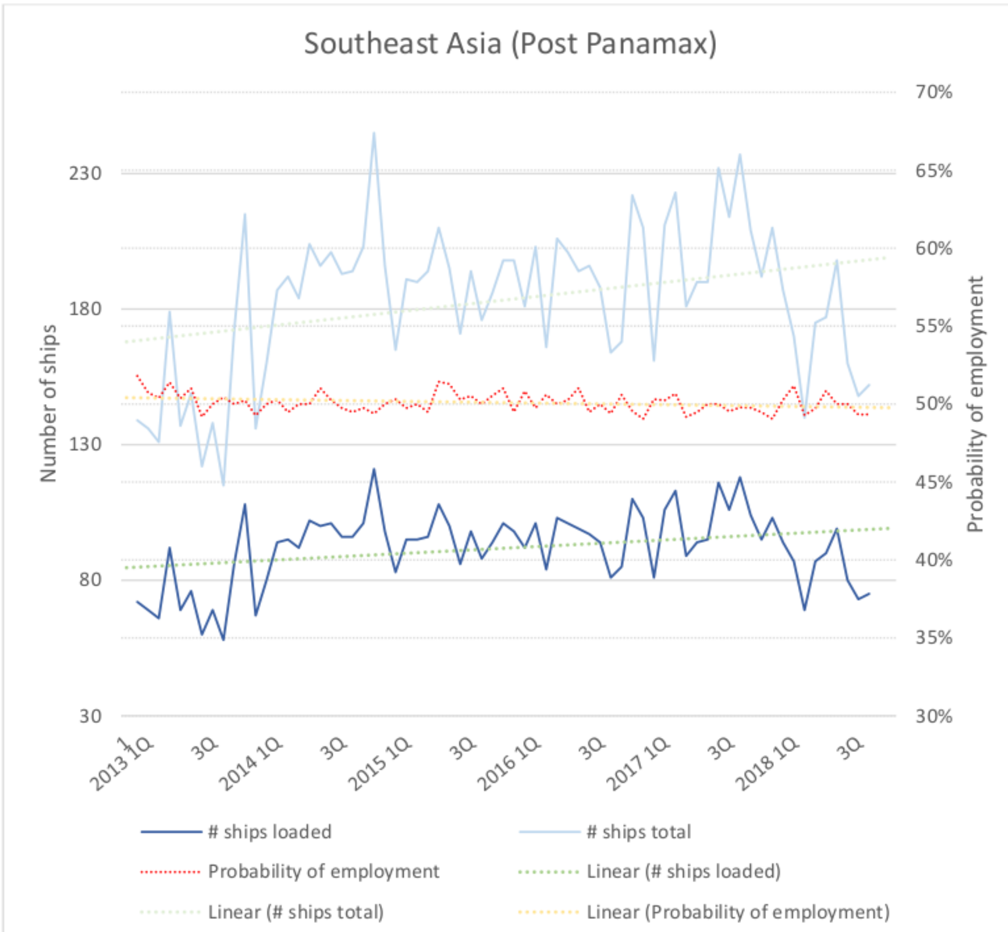


Figure 10. Probability of employment in Southeast Asia (Post Panamax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Table 10. Load zone to discharge zone mapping (Post Panamax)

LOAD ZONE	**Far East**		**Southeast Asia**		**Persian Gulf**	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	86	0.73%	760	10.22%	20	0.31%
Baltic	81	0.68%	103	1.39%	0	0.00%
Black Sea	28	0.24%	41	0.55%	2	0.03%
Caribbean	0	0.00%	1	0.01%	0	0.00%
East Africa	0	0.00%	0	0.00%	2	0.03%
East Australia	1100	9.29%	2	0.03%	4	0.06%
East Coast Canada	0	0.00%	0	0.00%	0	0.00%
ECCA	0	0.00%	5	0.07%	0	0.00%
East Coast India	1221	10.31%	32	0.43%	654	10.04%
ECSA	162	1.37%	803	10.80%	8	0.12%
East Coast U.S	0	0.00%	21	0.28%	8	0.12%
East Mediterranean	36	0.30%	291	3.91%	54	0.83%
Far East	8083	68.24%	2746	36.94%	4231	64.94%
French Atlantic	3	0.03%	55	0.74%	1	0.02%
Great Lakes	0	0.00%	0	0.00%	0	0.00%
Indian Ocean	1	0.01%	7	0.09%	0	0.00%
North Pacific	5	0.04%	3	0.04%	18	0.28%
NCSA	0	0.00%	124	1.67%	0	0.00%
North Continent	0	0.00%	2	0.03%	0	0.00%
Northwest Africa	0	0.00%	5	0.07%	0	0.00%
Persian Gulf	39	0.33%	567	7.63%	4	0.06%
Red Sea	15	0.13%	110	1.48%	3	0.05%
Saint Lawrence	0	0.00%	55	0.74%	0	0.00%
South Africa	21	0.18%	11	0.15%	1	0.02%
Southeast Asia	420	3.55%	956	12.86%	755	11.59%
Southwest Africa	1	0.01%	0	0.00%	0	0.00%
Spain Atlantic	3	0.03%	123	1.65%	1	0.02%
UK - Ireland	3	0.03%	102	1.37%	3	0.05%
USG	4	0.03%	277	3.73%	0	0.00%
West Australia	3	0.03%	0	0.00%	0	0.00%
WCCA	2	0.02%	23	0.31%	0	0.00%
West Coast India	454	3.83%	49	0.66%	698	10.71%
WCSA	62	0.52%	1	0.01%	0	0.00%
West Mediterranean	11	0.09%	157	2.11%	23	0.35%
Worldwide	1	0.01%	1	0.01%	25	0.38%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each. Worldwide zone refers to offshore installations in international water.

The Far East zone is also mapped as the topmost discharge zone when coming from the three most active load zones for the Post Panamax segment. The following are: Intrazonal trade in the Far East (68.24%), Persian Gulf to the Far East (64.94%). Transport from Southeast Asia is more diverse with Southeast Asia to Far East (36.94%), intrazonal (12.86%), ECSA (10.8%), and ARAG (10.2%), see Table 10. The Post Panamax segment shows a more promising load-discharge mapping for employment as the most active discharge zones (Far East and Southeast Asia) also record a high number of loading activity.

Chapter 4.4. Panamax Geographic Distribution

The Panamax market, primarily driven by coal trade, has displayed significant growth at the beginning of the research period due to the growing demand for firm thermal coal from China and India and supported by improvements in European imports, mainly the UK and Spain. At the end of the third quarter of 2013, the Panamax fleet numbered 2,288 vessels of a combined 179.9m DWT, up 6% since the start of that year. The combined Chinese iron ore and seaborne coal imports accounted for about 55% of total dry bulk trade growth (Clarkson Research, 2013). By 2015, measures to reduce air pollution has significantly impacted seaborne coal trade causing the first decline in trade activity for almost three decades. Meanwhile, European seaborne coal imports were undermined by the EU's Large Combustion Plant Directive, designed to reduce carbon emissions (Clarkson Research, 2015).

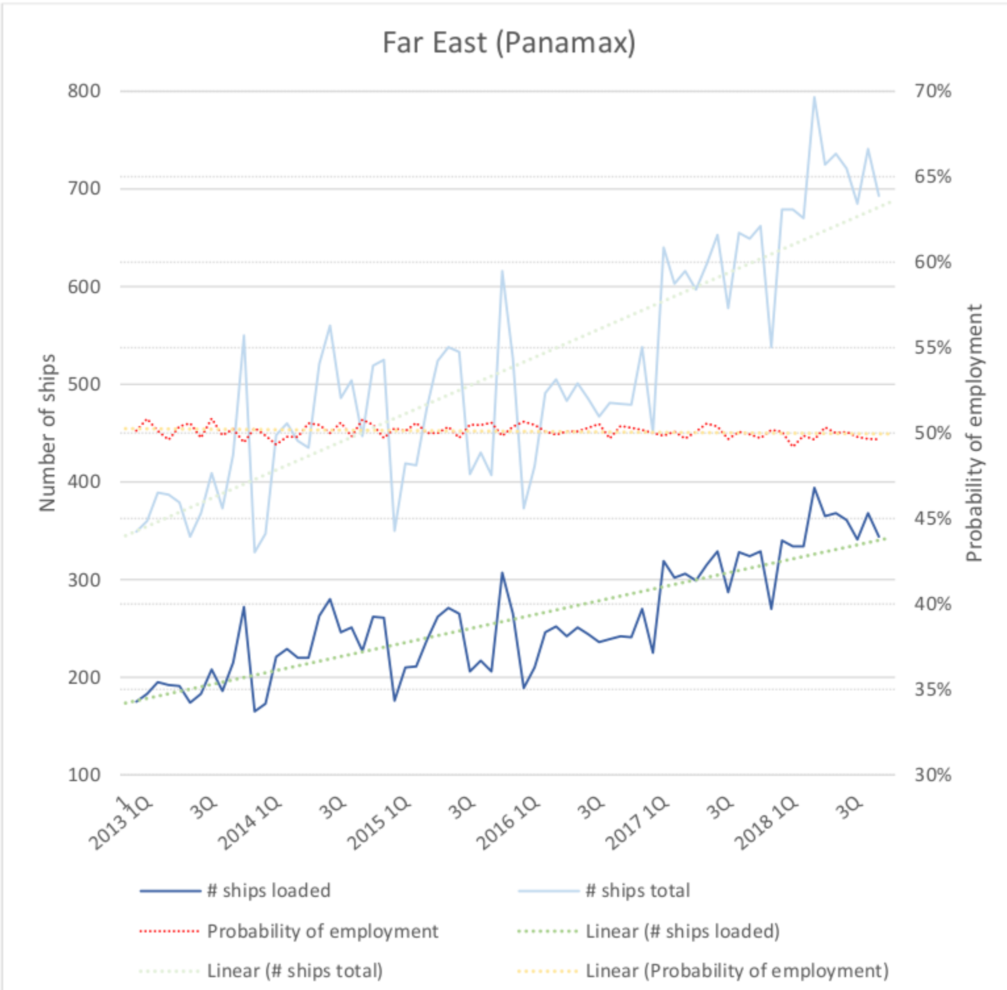
Table 11. Geographical distribution of trade activity for Panamax

Zone	LOADING %	Zone	DISCHARGE %
Far East	23.79%	**Far East**	49.02%
Southeast Asia	15.12%	**Southeast Asia**	6.28%
ECSA	11.91%	**East Coast India**	5.76%
East Australia	6.91%	ARAG	5.24%
North Pacific	5.71%	Persian Gulf	4.15%
US Gulf	5.09%	West Coast India	3.40%
Persian Gulf	3.70%	ECSA	3.32%
Baltic	3.55%	US Gulf	3.06%
Black Sea	2.84%	East Mediterranean	2.97%
West Australia	2.82%	West Mediterranean	1.31%
Others	18.52%	Others	15.45%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

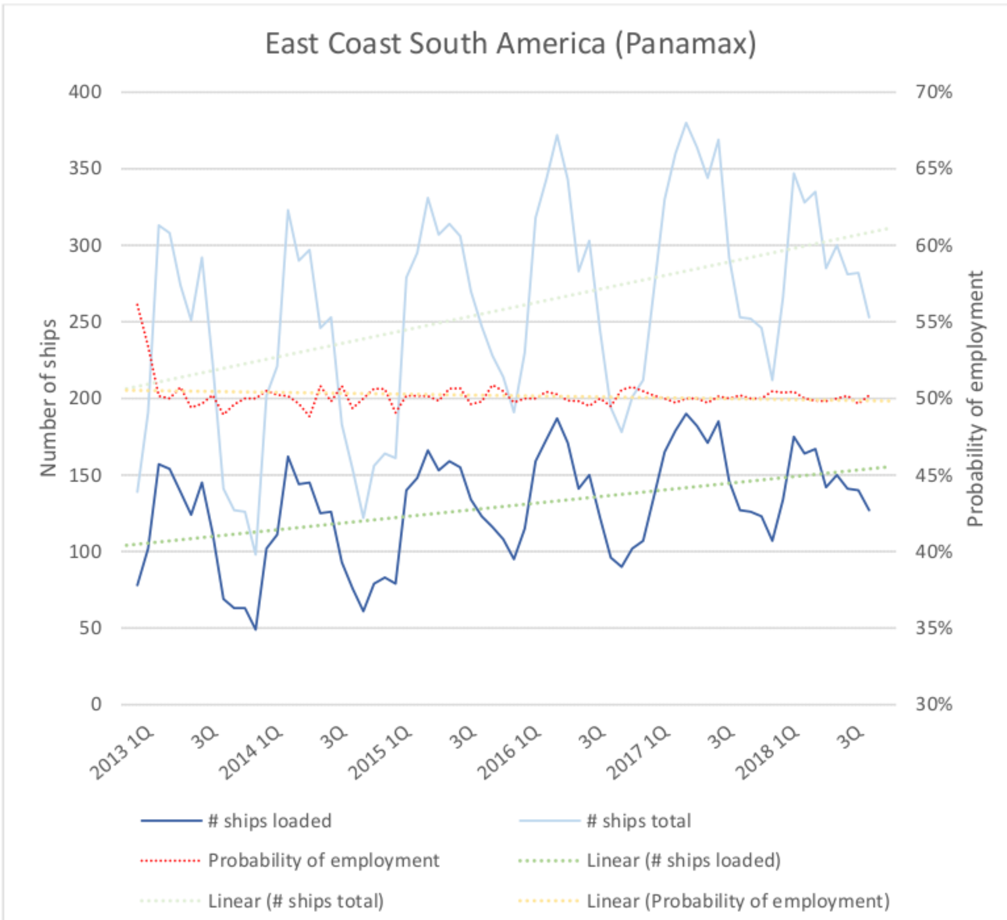
The Far East recorded the most number of Panamax employment during the research period, with ships being loaded at ports in China to transport coal. Most vessel movements, however, are intranational, i.e., Qinhuangdao to Nansha, Huanghua to Taixing, Jinzhou to Shekou. The Far East also recorded the most number of Panamax ships discharging in its zone; it is because in addition to its intranational movement, ships from major coal exporters like Australia and Indonesia are also routed to China to unload cargo. Probability of employment in that zone remains steady at 50% despite increased activity over time (Figure 11).

Figure 11. Probability of employment in Southeast Asia (Panamax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

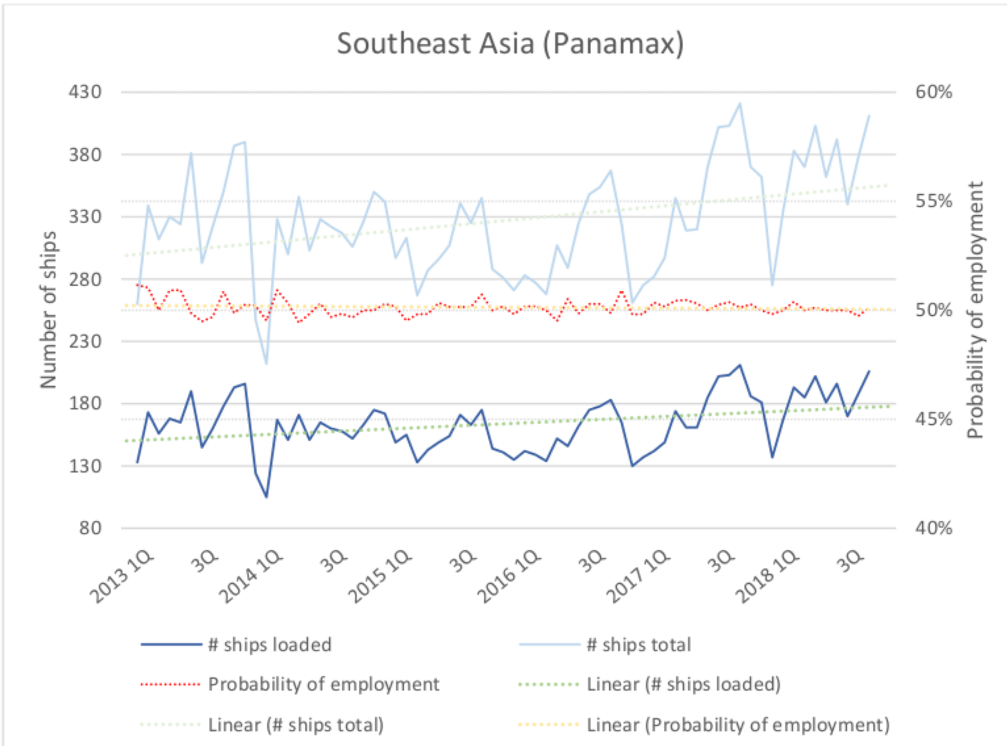
Figure 12. Probability of employment in East Coast South America (Panamax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Much like the trade activity in East Coast South America for the Post Panamax segment, the same can be said for the Panamax. Seasonality due to the harvest cycle of agricultural products is evident and peaks at the second quarter of each year (Figure 12).

Figure 13. Probability of employment in Southeast Asia (Panamax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Southeast Asia recorded 15.1% of loading percentage in the Panamax segment during the research period (Table 11), with more than half for commodity transport to the Far East and less than a quarter for intra-regional trade. Its primary activity is the export of coal. Other exported commodity recorded is steam coal, nickel ore, iron ore and other minor bulks that include sand, limestone, wood ships, and palm kernel expeller. The firm increase of imports into China and India supported the last quarter of 2018 with spot earnings peaking at over 16,000 USD per day, resulting to a full year average of 12,866 USD per day—the highest level since 2010 (Clarkson Research, 2018)

Table 12. Load zone to discharge zone mapping (Panamax)

LOAD ZONE	Far East		Southeast Asia		ECSA	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	148	0.80%	100	0.85%	605	6.55%
Baltic	2	0.01%	1	0.01%	129	1.40%
Black Sea	36	0.20%	15	0.13%	47	0.51%
Caribbean	1	0.01%	0	0.00%	2	0.02%
East Africa	53	0.29%	18	0.15%	5	0.05%
East Australia	97	0.53%	8	0.07%	26	0.28%
East Coast Canada	0	0.00%	0	0.00%	0	0.00%
ECCA	41	0.22%	3	0.03%	10	0.11%
East Coast India	345	1.87%	1036	8.81%	165	1.79%
WCSA	167	0.91%	9	0.08%	1002	10.85%
East Coast U.S	14	0.08%	10	0.09%	51	0.55%
East Mediterranean	143	0.78%	78	0.66%	501	5.43%
Far East	15830	85.80%	7167	60.97%	3492	37.81%
French Atlantic	0	0.00%	2	0.02%	75	0.81%
Great Lakes	0	0.00%	0	0.00%	0	0.00%
Indian Ocean	20	0.11%	13	0.11%	14	0.15%
Mid-North Atlantic	0	0.00%	0	0.00%	1	0.01%
New Zealand	1	0.01%	6	0.05%	5	0.05%
North Pacific	37	0.20%	29	0.25%	48	0.52%
NCSA	9	0.05%	0	0.00%	91	0.99%
North Continent	0	0.00%	0	0.00%	19	0.21%
Northwest Africa	3	0.02%	2	0.02%	36	0.39%
Persian Gulf	102	0.55%	17	0.14%	529	5.73%
Red Sea	36	0.20%	5	0.04%	170	1.84%
Saint Lawrence	2	0.01%	0	0.00%	173	1.87%
South Africa	32	0.17%	32	0.27%	71	0.77%
Southeast Asia	403	2.18%	2009	17.09%	922	9.98%
Southwest Africa	91	0.49%	23	0.20%	12	0.13%
Spain Atlantic	44	0.24%	6	0.05%	176	1.91%
UK - Ireland	11	0.06%	20	0.17%	150	1.62%
USG	216	1.17%	9	0.08%	311	3.37%
West Australia	54	0.29%	2	0.02%	11	0.12%
WCCA	95	0.51%	6	0.05%	3	0.03%
West Coast India	289	1.57%	1050	8.93%	89	0.96%
WCSA	99	0.54%	19	0.16%	64	0.69%
West Mediterranean	28	0.15%	30	0.26%	230	2.49%
Worldwide	1	0.01%	29	0.25%	0	0.00%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

The Far East zone is also mapped as the topmost zone when coming from the three most active load zones for the Post Panamax segment. The following are: Intrazonal trade in the Far East (68.24%), Southeast Asia to Far East (36.94%), Persian Gulf to the Far East (64.94%). Transport from Southeast Asia is more diverse with intrazonal (12.86%), ECSA (10.8%), and ARAG (10.2%). The load-discharge mapping for this segment shows a high probability of ships employment from load to discharge zone and back as both load zone and its corresponding discharge zone show high activity percentage.

Chapter 4.5. Supramax Geographic Distribution

Supramax ships are versatile in a sense that its size allows it to be accommodated by majority of the ports around the world, it can transit the Panama and the Suez Canals allowing it access to primary trade routes, and it can carry different types of bulk cargo at the same time through its design and construction of multiple watertight holds. For instance, a Supramax vessel with five cargo holds can have three holds carry iron ore while the other two carry grain. The geographic zones with the highest recorded trade activity for loading are Far East (25.6%), Southeast Asia (18.9%), and Persian Gulf (7.9%); for discharging are Far East (41.3%), Southeast Asia (9.4%), and East Coast India (8.2%), see Table 13.

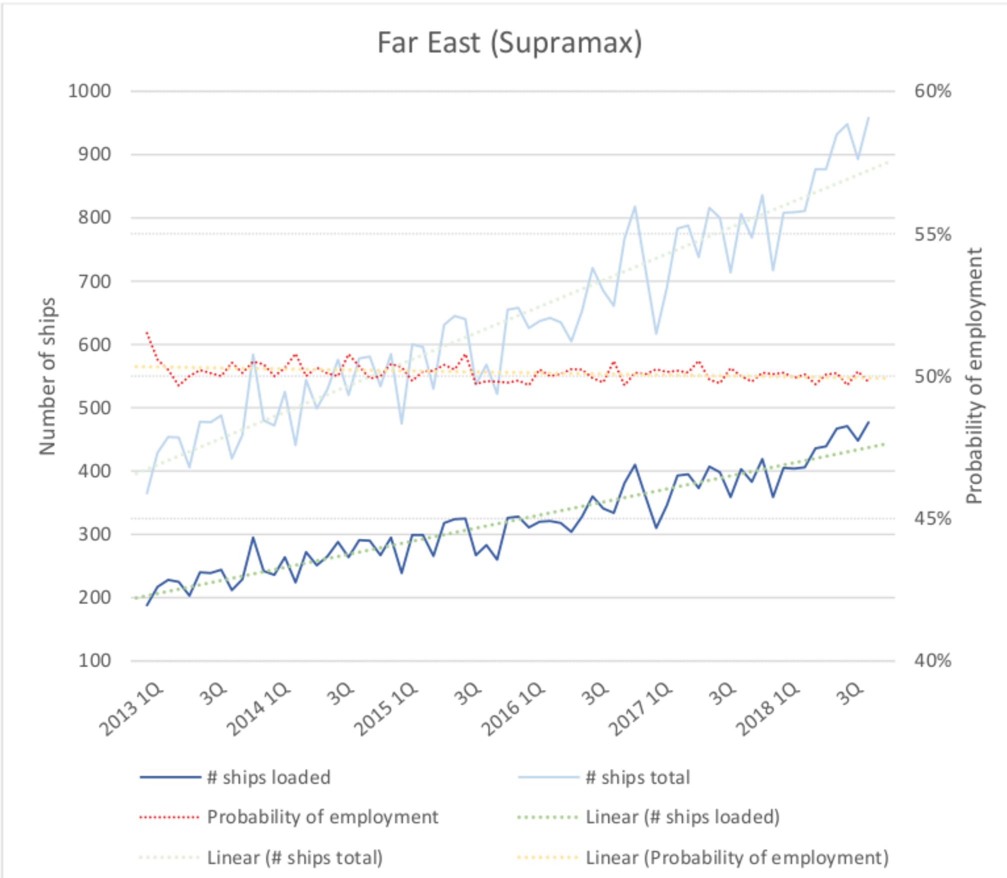
Table 13. Geographical distribution of trade activity for Supramax

	LOADING		DISCHARGE
Zone	%	Zone	%
Far East	**25.63%**	**Far East**	**41.30%**
Southeast Asia	**18.92%**	**Southeast Asia**	**9.37%**
Persian Gulf	**7.92%**	**East Coast India**	**8.19%**
ECSA	6.59%	West Coast India	6.19%
US Gulf	5.17%	Persian Gulf	4.43%
East Australia	3.74%	East Mediterranean	2.99%
Black Sea	3.62%	US Gulf	2.66%
North Pacific	3.29%	South West Africa	2.63%
South Africa	3.21%	ECSA	2.53%
East Coast India	2.84%	ARAG	2.06%
Others	19.07%	Others	17.37%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

The average probability of employment for all three high zones that recorded the highest activity is 50%. Ship supply and transport demand in the Far East have continuously grown during the research period. The main commodity transported is coal primarily for intrazonal trade. Other notable commodities transported was steel, fertilizers, and cement.

Figure 14. Probability of employment in Far East (Supramax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Commodities loaded in the Southeast Asia zone are also mostly bound for the Far East, with a percentage for intrazonal trade and for export to East Coast India. The transported commodities coming from the Southeast Asia are coal, steam coal, and nickel ore. Indonesia leads the zone in coal production and export. In the Persian Gulf, 17% of total loaded commodity is iron ore, another 17% is aggregates and limestone, 10% urea, 8% Sulphur, and the remaining are other minor bulks. The discharge zones for the loaded commodity is in Table 14. Both zones has an average employment probability of 50% but Southeast Asia has about twice as much load activity and total number of ships than that of the Persian Gulf. (Graphs 14 and 15)

Figure 15. Probability of employment in Southeast Asia (Supramax)

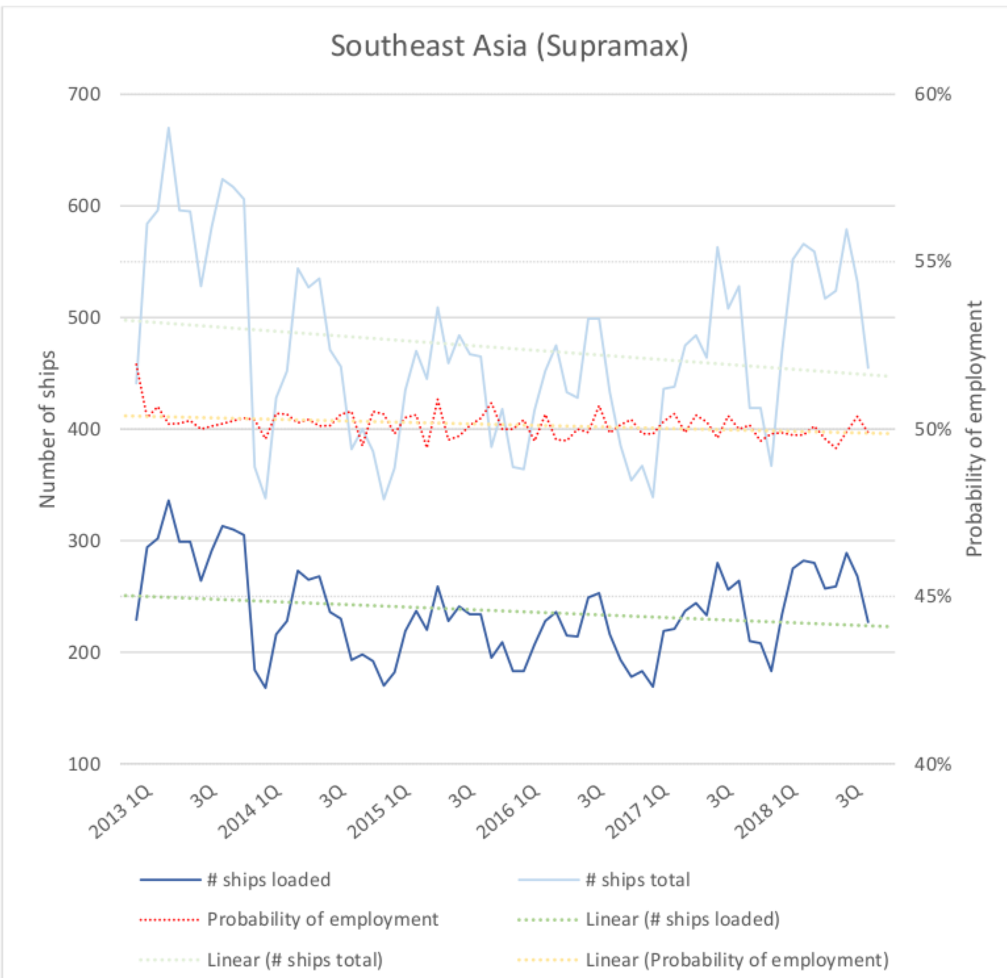
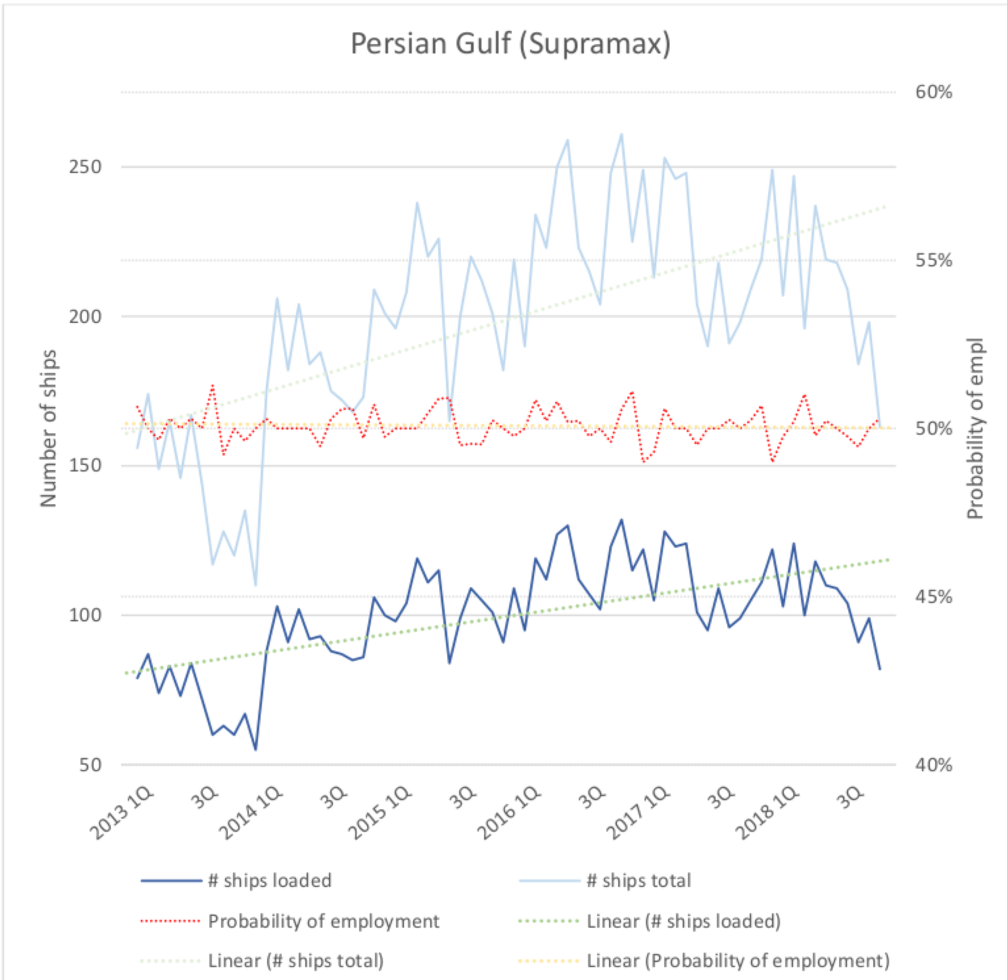


Figure 16. Probability of employment in Persian Gulf (Supramax)



Note: The line graphs display the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Table 14. Load zone to discharge zone mapping (Panamax)

LOAD ZONE	Far East		Southeast Asia		Persian Gulf	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
USG	490	2.13%	39	0.23%	172	2.43%
Far East	14700	63.97%	8949	52.80%	1486	21.01%
East Coast India	580	2.52%	2246	13.25%	1310	18.52%
East Australia	174	0.76%	95	0.56%	56	0.79%
ARAG	137	0.60%	77	0.45%	9	0.13%
Persian Gulf	866	3.77%	102	0.60%	1618	22.88%
Southeast Asia	2117	9.21%	3162	18.66%	304	4.30%
South Africa	99	0.43%	43	0.25%	84	1.19%
East Coast U.S	126	0.55%	13	0.08%	30	0.42%
NCSA	47	0.20%	2	0.01%	1	0.01%
Southwest Africa	492	2.14%	189	1.12%	11	0.16%
West Mediterranean	59	0.26%	1	0.01%	20	0.28%
ECSA	175	0.76%	11	0.06%	265	3.75%
Spain Atlantic	79	0.34%	9	0.05%	10	0.14%
WCSA	434	1.89%	78	0.46%	4	0.06%
West Australia	72	0.31%	15	0.09%	8	0.11%
West Coast India	755	3.29%	1622	9.57%	838	11.85%
Saint Lawrence	10	0.04%	2	0.01%	2	0.03%
East Africa	177	0.77%	66	0.39%	338	4.78%
Black Sea	100	0.44%	19	0.11%	9	0.13%
WCCA	283	1.23%	7	0.04%	6	0.08%
East Mediterranean	310	1.35%	39	0.23%	80	1.13%
UK - Ireland	26	0.11%	13	0.08%	0	0.00%
ECCA	183	0.80%	5	0.03%	1	0.01%
New Zealand	15	0.07%	47	0.28%	10	0.14%
Red Sea	195	0.85%	31	0.18%	203	2.87%
Northwest Africa	25	0.11%	7	0.04%	172	2.43%
Baltic	4	0.02%	0	0.00%	1	0.01%
North Pacific	172	0.75%	18	0.11%	14	0.20%
Indian Ocean	60	0.26%	27	0.16%	6	0.08%
North Continent	0	0.00%	8	0.05%	0	0.00%
French Atlantic	4	0.02%	2	0.01%	4	0.06%
East Coast Canada	0	0.00%	0	0.00%	0	0.00%
Caribbean	14	0.06%	0	0.00%	0	0.00%
Mid-North Atlantic	0	0.00%	0	0.00%	0	0.00%
Worldwide	1	0.00%	4	0.02%	0	0.00%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

For the first time since all previous load-to-discharge zone mapping, the Far East has not recorded the highest discharge activity as 22.9% of the commodities loaded from the Persian Gulf are traded intrazonal, but comes in close second at 21.0%, while East Coast India takes third place at 18.52%. The Far East, however, dwarfs the number of discharge activity of all other zones for cargoes loaded from Southeast Asia and the Far East itself. 63.97% of commodities loaded in the Far East are traded intrazonal. While 52.8% of that from Southeast Asia are also bound for the Far East. And much like the previous segment, the load-discharge mapping of zones with highest activity shows high probability of ships to be employed in its return voyage.'

Chapter 4.6. Handymax Geographic Distribution

Handymax vessels have a cargo-carrying capacity of 40,000 to 50,000 DWT tons and share the same class as that of the bigger Supramax. The geographical distribution of the Handymax and Supramax have stark similarities apart from the Supramax being more active in the Persian Gulf and the Handymax being more active in the ECSA. The cargoes loaded by the Handymax in order of highest to lowest recorded trade activity are: coal, iron ore, wood chips, steels, grain, wood pulp, and other minor bulk cargoes.

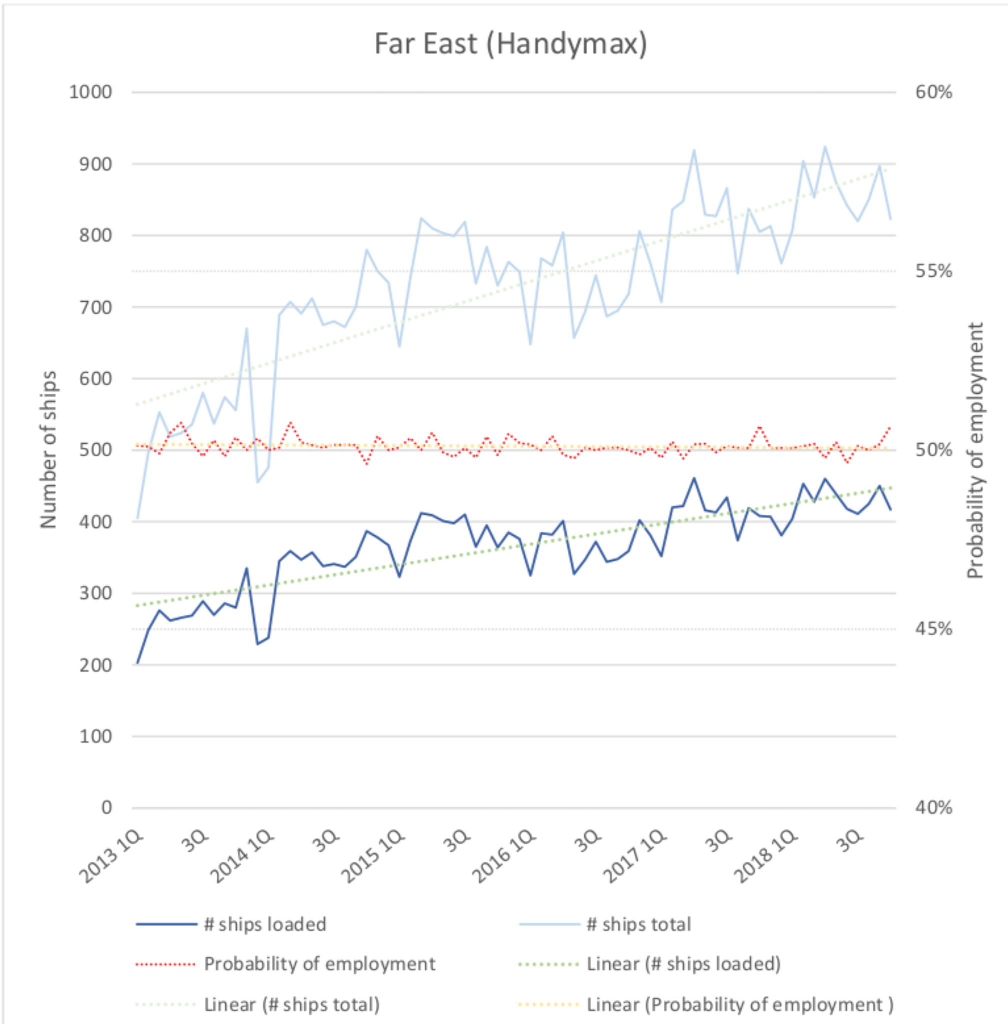
Table 15. Geographical distribution of trade activity for Handymax

Zone	LOADING %	Zone	DISCHARGE %
Far East	**56.12%**	**Far East**	**64.49%**
Southeast Asia	**10.61%**	**Southeast Asia**	**5.39%**
ECSA	**4.94%**	**EC India**	**3.72%**
Persian Gulf	3.99%	Persian Gulf	3.12%
Black Sea	3.04%	ARAG	2.61%
East Australia	1.88%	East Mediterranean	2.43%
North Pacific	1.69%	ECSA	1.98%
USG	1.59%	SW Africa	1.54%
East Coast India	1.52%	NW Africa	1.49%
North West Africa	1.49%	USEC	1.37%
Others	13.14%	Others	11.85%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

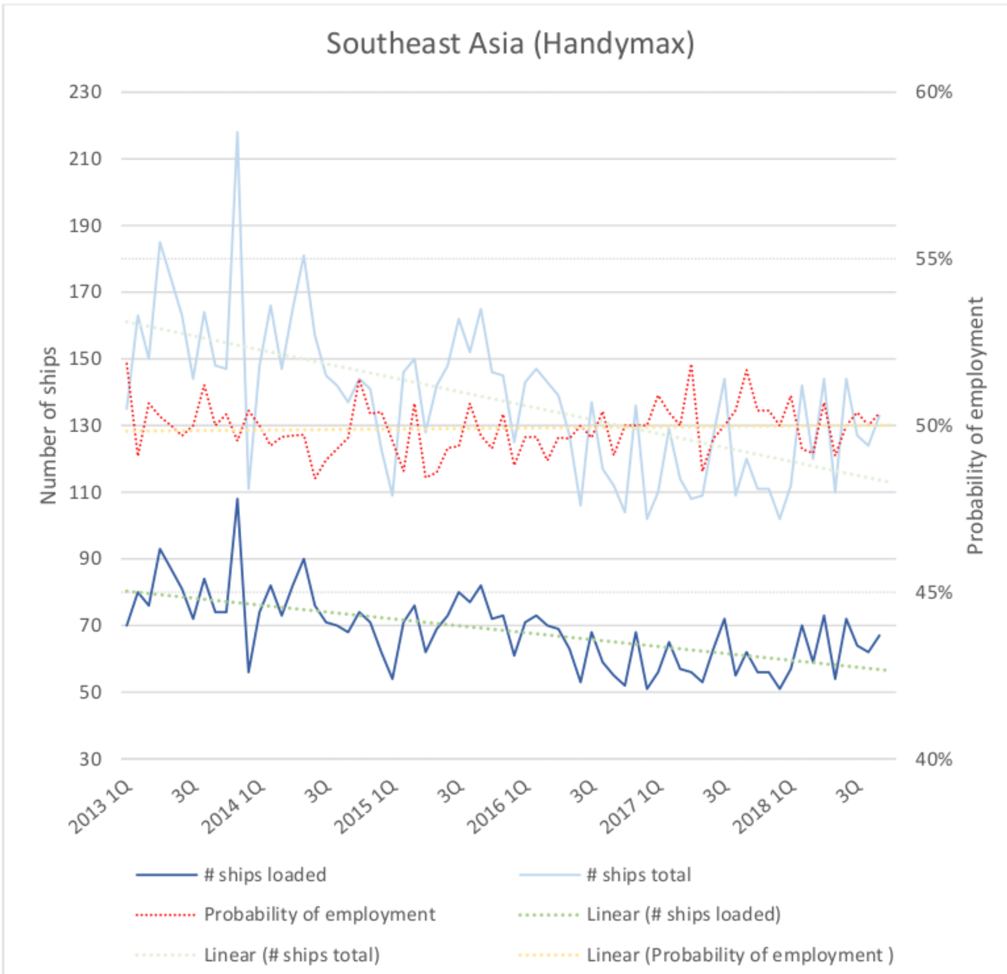
The number of ships in the Far East zone (Graph 16) has shown a steady increase since the start of the research period up to 2018 but the average probability of employment remained at 50%. Majority of the activity recorded are trades of minor bulk to and from Chinese ports. The growth trend in the number of ships operating in the Far East is opposite to the trend in the next two active zones: Southeast Asia and ECSA (Graphs 17 and 18). The number of ships on record that traded in Southeast Asia and ECSA, despite still being less than half of the number of ships in the Far East when combined, has gradually declined, paired with a fluctuating probability of employment of +/- 2% from the average 50%.

Figure 17. Probability of employment in Far East (Handymax)



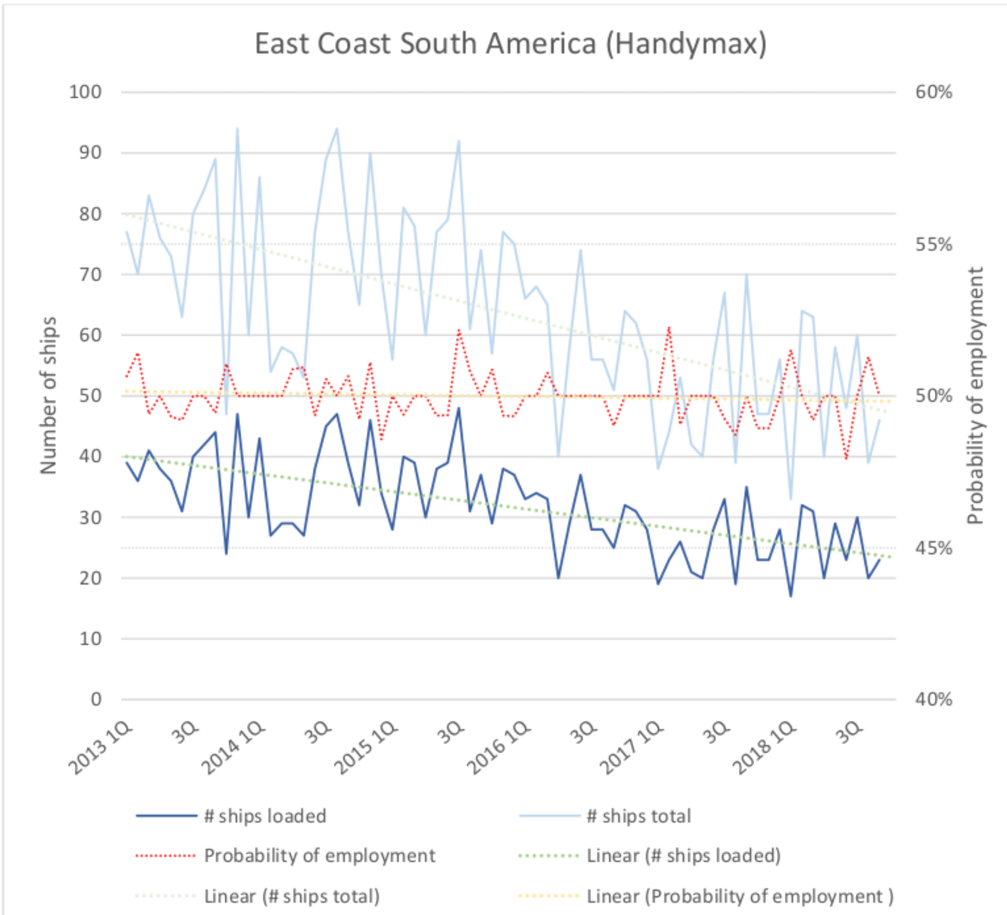
Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 18. Probability of employment in Southeast Asia (Handymax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 19. Probability of employment in East Coast South America (Handymax)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Table 16. Load zone to discharge zone mapping (Handymax)

LOAD ZONE	**Far East**		**Southeast Asia**		**ECSA**	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	24	0.09%	13	0.27%	351	15.46%
Baltic	1	0.00%	5	0.10%	54	2.38%
Black Sea	17	0.07%	4	0.08%	44	1.94%
Caribbean	6	0.02%	1	0.02%	8	0.35%
East Africa	37	0.14%	7	0.14%	3	0.13%
East Australia	16	0.06%	4	0.08%	2	0.09%
East Coast Canada	0	0.00%	0	0.00%	0	0.00%
ECCA	15	0.06%	2	0.04%	6	0.26%
East Coast India	386	1.49%	386	7.88%	22	0.97%
ECSA	71	0.27%	1	0.02%	328	14.44%
East Coast U.S	18	0.07%	1	0.02%	96	4.23%
East Mediterranean	55	0.21%	9	0.18%	146	6.43%
Far East	23443	90.67%	3087	63.03%	369	16.25%
French Atlantic	0	0.00%	0	0.00%	34	1.50%
Great Lakes	0	0.00%	0	0.00%	0	0.00%
Indian Ocean	2	0.01%	1	0.02%	3	0.13%
New Zealand	3	0.01%	4	0.08%	2	0.09%
North Pacific	82	0.32%	3	0.06%	4	0.18%
NCSA	11	0.04%	0	0.00%	42	1.85%
North Continent	3	0.01%	8	0.16%	24	1.06%
Northwest Africa	10	0.04%	12	0.24%	36	1.59%
Northwest Passage	0	0.00%	0	0.00%	0	0.00%
Persian Gulf	258	1.00%	54	1.10%	39	1.72%
Red Sea	34	0.13%	31	0.63%	55	2.42%
Saint Lawrence	0	0.00%	0	0.00%	15	0.66%
South Africa	18	0.07%	5	0.10%	25	1.10%
Southeast Asia	906	3.50%	1097	22.40%	79	3.48%
Southwest Africa	163	0.63%	82	1.67%	34	1.50%
Spain Atlantic	9	0.03%	2	0.04%	59	2.60%
UK - Ireland	5	0.02%	3	0.06%	17	0.75%
USG	43	0.17%	4	0.08%	87	3.83%
West Australia	3	0.01%	1	0.02%	1	0.04%
WCCA	53	0.20%	2	0.04%	5	0.22%
West Coast India	96	0.37%	64	1.31%	23	1.01%
WCSA	56	0.22%	2	0.04%	46	2.03%
West Mediterranean	10	0.04%	1	0.02%	212	9.34%
Worldwide	0	0.00%	2	0.04%	0	0.00%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

The load-to-discharge mapping created for the Handymax segment shows the following routes: Intrazonal trade in the Far East (90.67%), Southeast Asia to the Far East (63%), intrazonal trade in Southeast Asia (22.4%). On the other hand, routes coming from ECSA are more widely distributed with ECSA-ECSA (14.44%), ECSA-Far East (16.25%), and ECSA-ARAG (15.46%). Probability of employment in all three load-active zones are averaged at 50% but those trading in the Far East has more recorded load activity than Southeast Asia and ECSA, meaning that ships coming from the Southeast Asia and ECSA to the Far East are better off remaining in the Far East than be employed to transit back. This may be the reason why there is a steady increase of ships in the Far East and a steady decline of ships in the other zones.

Chapter 4.7. Handysize Geographic Distribution

Handysize bulk carriers has the cargo-carrying capacity of between 20,000-40,000 DWT tons. Typically fitted with onboard cranes, it has the unique advantage of being able to perform deep sea voyages yet still call on smaller ports with lacking cargo-loading infrastructure and shallow draft restriction. Ships in this segment transport all manner of bulk cargo that includes minerals, ores, wood chips, fertilizers, grains, cement, and numerous other minor niche dry bulk. The geographical distribution for this segment is displayed in Table 17.

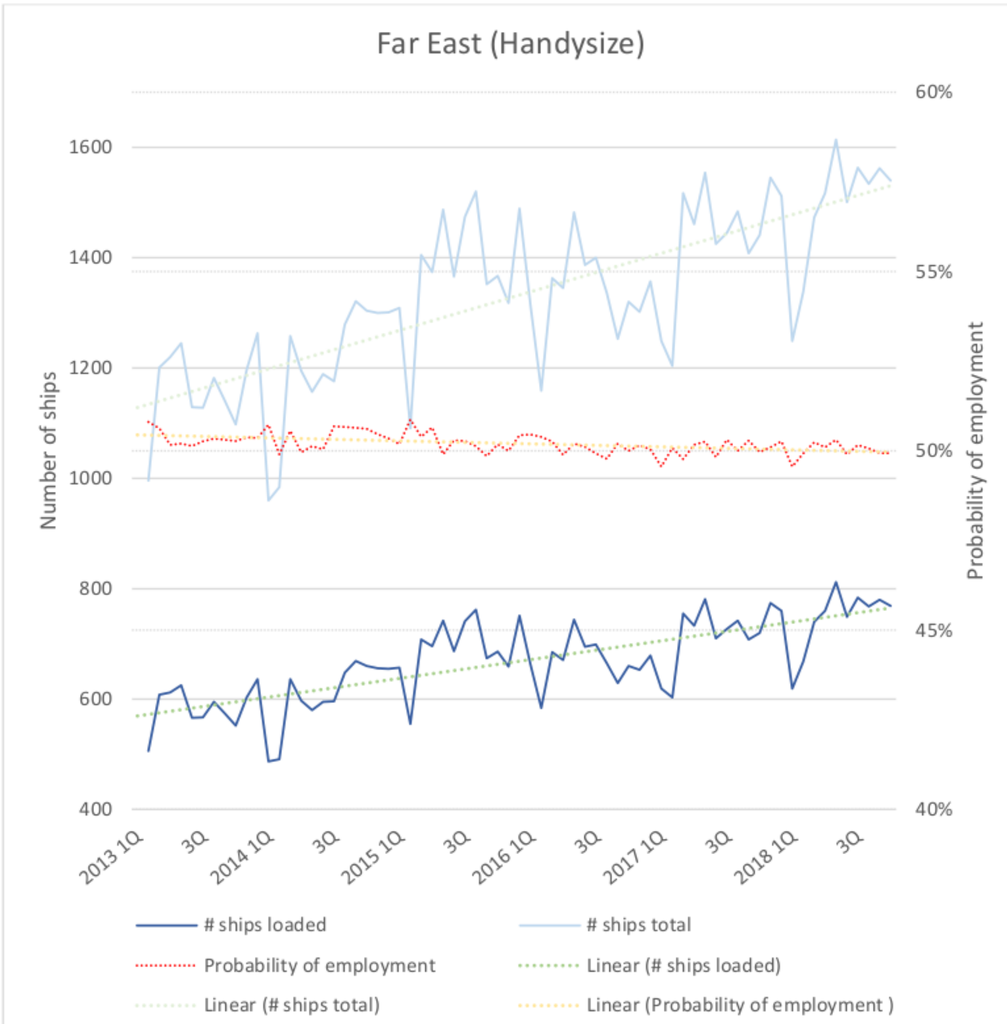
Table 17. Geographical distribution of trade activity for Handysize

Zone	LOADING %	Zone	DISCHARGE %
Far East	**25.92%**	**Far East**	**24.35%**
Baltic	**15.68%**	**ARAG**	**12.96%**
Black Sea	**11.48%**	**Baltic**	**12.67%**
ARAG	10.78%	Black Sea	7.72%
Southeast Asia	6.49%	East Mediterranean	7.19%
North Continent	5.12%	Southeast Asia	6.33%
East Mediterranean	4.97%	West Mediterranean	4.70%
West Mediterranean	3.94%	North Continent	3.58%
Spain Atlantic	3.57%	UK - Ireland	3.13%
United Kingdom Ireland	2.40%	Spain Atlantic	2.49%
Others	9.64%	Others	14.86%
	100%		100%

Note: The loading and discharge percentages are calculated from the total number of ship activity in the geographic zone during the period.

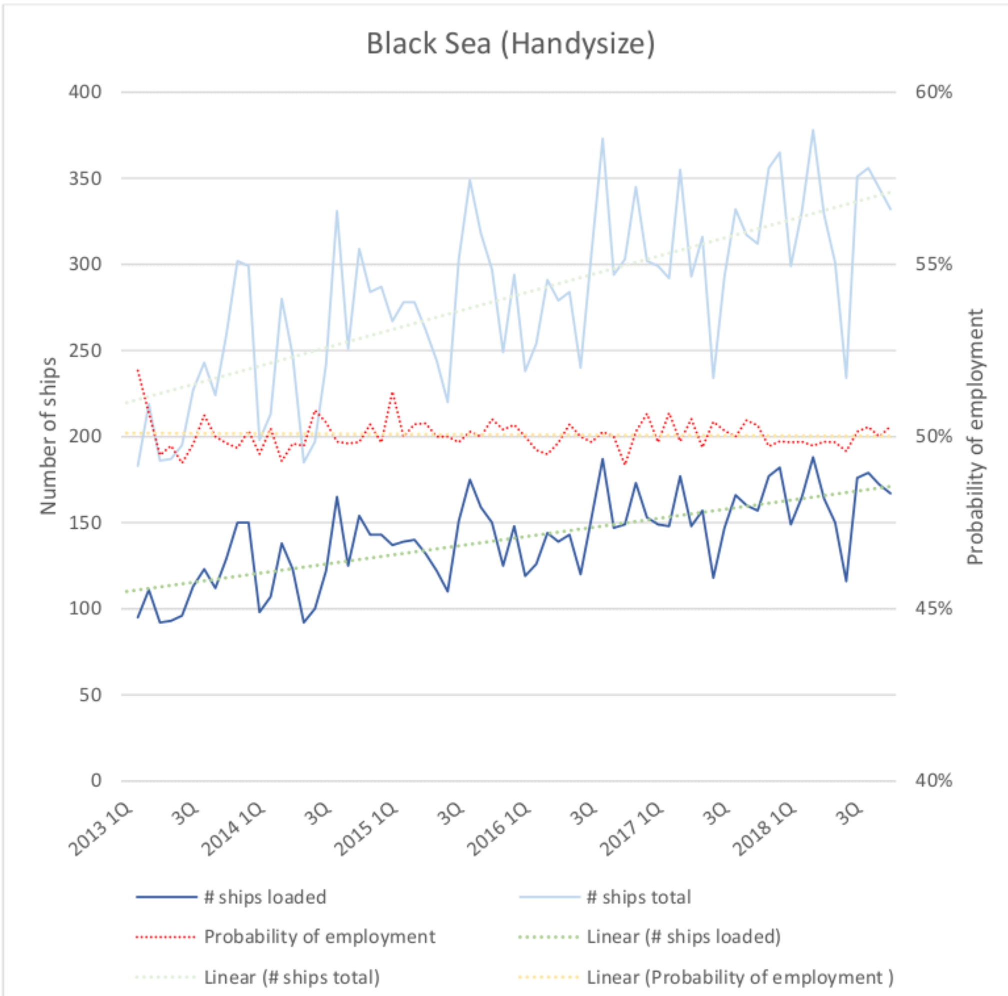
The loading percentage in the Far East (25.92%) is around as much as the combined percentages of the next two zones with high recorded load activity (Black Sea, 15.68%, and Handysize, 11.48%). All three zones display an increasing trend in total number of ships and in number of ships loaded, and at the same time maintaining an average probability of employment of 50%.

Figure 20. Probability of employment in Far East (Handysize)



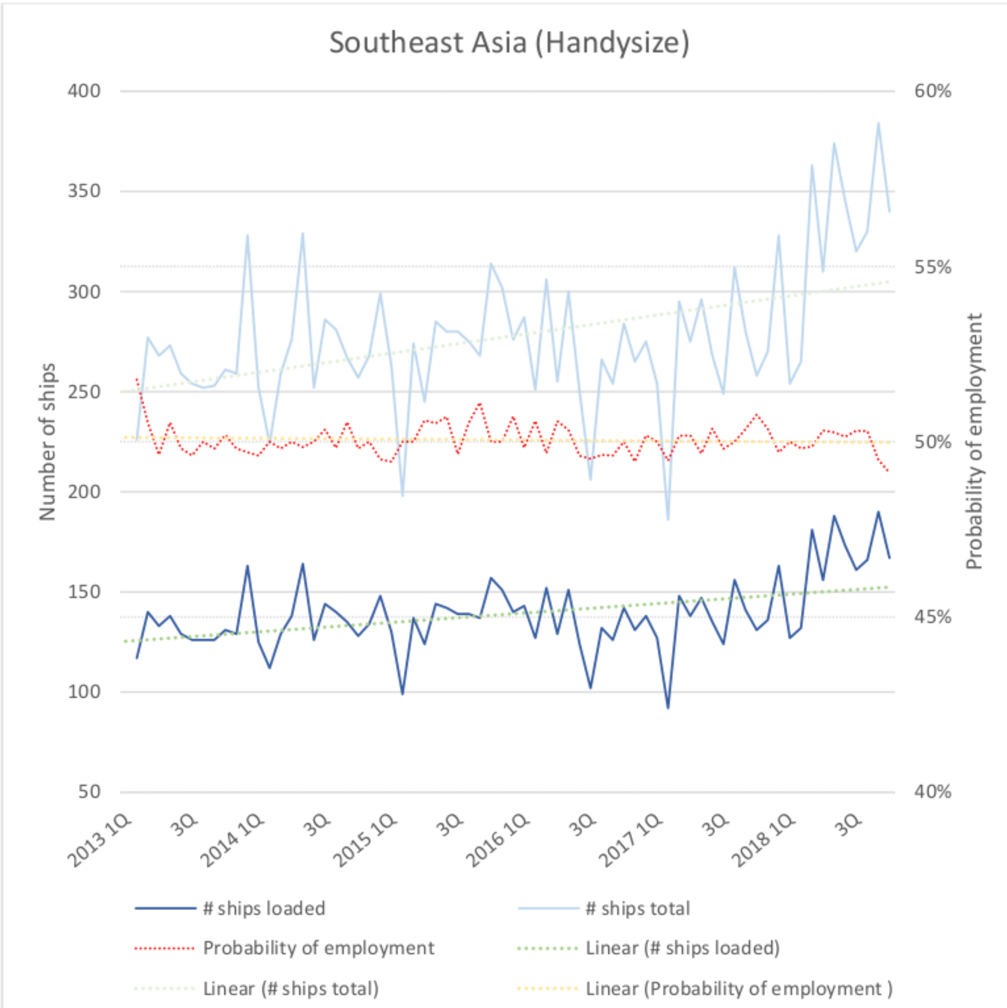
Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 21. Probability of employment in Black Sea (Handysize)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis.

Figure 22. Probability of employment in Southeast Asia (Handysize)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis

Table 18. Load zone to discharge zone mapping (Handysize)

LOAD ZONE	Far East		Black Sea		Southeast Asia	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
ARAG	140	0.29%	542	5.39%	32	0.32%
Baltic	17	0.04%	56	0.56%	22	0.22%
Black Sea	79	0.17%	1110	11.03%	22	0.22%
Caribbean	66	0.14%	40	0.40%	49	0.49%
East Africa	174	0.36%	58	0.58%	56	0.56%
East Australia	619	1.30%	2	0.02%	157	1.57%
East Coast Canada	0	0.00%	2	0.02%	0	0.00%
East Coast Central America	98	0.21%	100	0.99%	7	0.07%
East Coast India	705	1.48%	108	1.07%	649	6.48%
East Coast South America	219	0.46%	138	1.37%	19	0.19%
East Coast U.S	128	0.27%	107	1.06%	67	0.67%
East Mediterranean	180	0.38%	4168	41.41%	54	0.54%
Far East	36716	77.01%	108	1.07%	4200	41.95%
French Atlantic	2	0.00%	56	0.56%	0	0.00%
Great Lakes	15	0.03%	35	0.35%	0	0.00%
Indian Ocean	13	0.03%	6	0.06%	12	0.12%
Mid Pacific	20	0.04%	0	0.00%	2	0.02%
Mid-North Atlantic	0	0.00%	13	0.13%	1	0.01%
New Zealand	240	0.50%	2	0.02%	468	4.67%
North Pacific	776	1.63%	21	0.21%	66	0.66%
North Coast South America	85	0.18%	33	0.33%	2	0.02%
North Continent	10	0.02%	3	0.03%	0	0.00%
Northwest Africa	31	0.07%	385	3.83%	44	0.44%
Northwest Passage	0	0.00%	1	0.01%	0	0.00%
Persian Gulf	744	1.56%	225	2.24%	272	2.72%
Red Sea	282	0.59%	277	2.75%	95	0.95%
Saint Lawrence	48	0.10%	72	0.72%	6	0.06%
South Africa	37	0.08%	21	0.21%	27	0.27%
Southeast Asia	4103	8.61%	59	0.59%	2878	28.75%
South Pacific	0	0.00%	0	0.00%	3	0.03%
South West Africa	357	0.75%	232	2.31%	287	2.87%
Spain Atlantic	34	0.07%	363	3.61%	8	0.08%
United Kingdom Ireland	16	0.03%	201	2.00%	24	0.24%
US Gulf	231	0.48%	222	2.21%	70	0.70%
West Australia	184	0.39%	0	0.00%	59	0.59%
West Coast Central America	518	1.09%	25	0.25%	7	0.07%
West Coast India	428	0.90%	61	0.61%	319	3.19%
West Coast South America	291	0.61%	47	0.47%	17	0.17%
West Mediterranean	72	0.15%	1165	11.58%	11	0.11%
Worldwide	1	0.00%	0	0.00%	0	0.00%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

The load-discharge zone mapping for the Handysize segment (Table 18) shows intrazonal trade in the Far East as the primary activity in the zone with 77.01% occurrence, followed only by transport to Southeast Asia (8.61%). Ships loaded in the Black Sea, however, are directed to the East Mediterranean almost half of the time (41.95%). Arriving at East Mediterranean, however, meant that there are less trade activity as recorded loading percentage in that zone is only 4.97% (Table 17). Load-discharge mapping for ships loaded in Southeast Asia is more promising as they are directed to the Far East 41.95% of the time, and will therefore be in the zone with the highest number of load percentage for the segment.

Chapter 4.8. Minibulk Geographic Distribution

Minibulk are smaller bulk cargo ships with sizes that range from 2,000 to 20,000 DWT tons specializing in carrying smaller cargo quantity on shorter routes, smaller ports, and shallower waters inaccessible to its bigger bulk carrier counterparts (Eyre, 2006). Table 19 shows the zones with the most trade activity and it can be observed that the load zones with the highest activities are the same as the discharge zones, indicating that the Minibulk is operating in intrazonal trade.

Table 19. Geographical distribution of trade activity for Minibulk

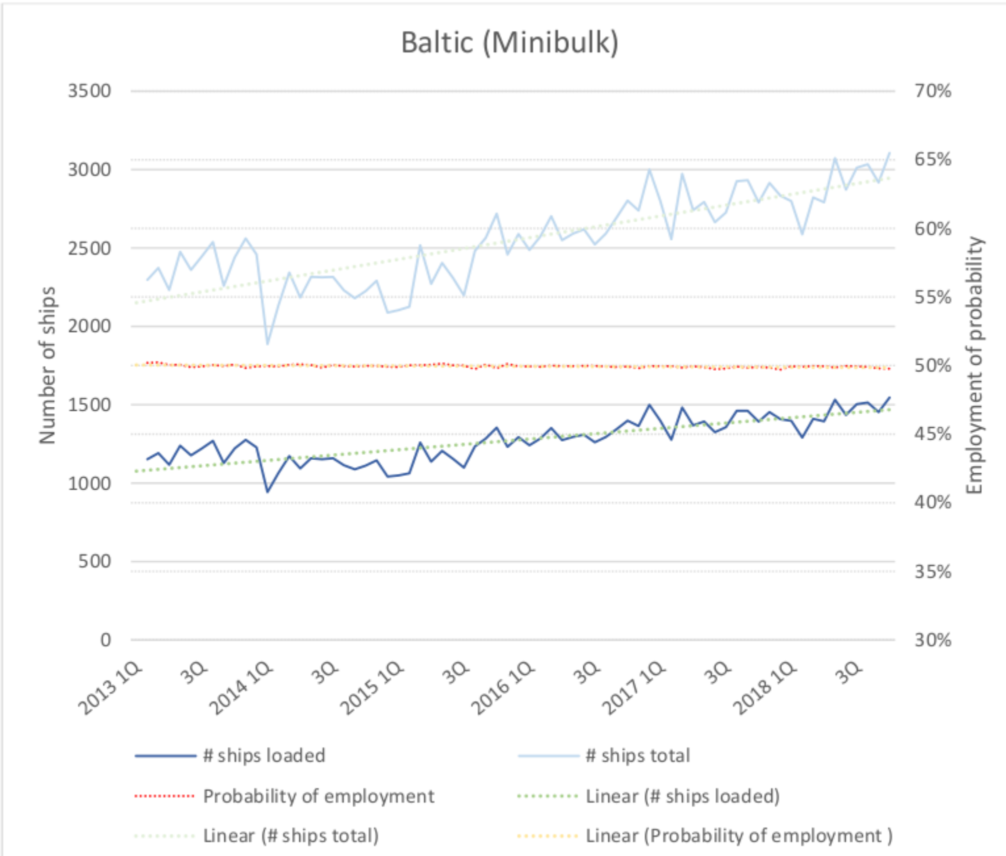
Zone	LOADING %	Zone	DISCHARGE %
Far East	**25.92%**	**Far East**	**24.35%**
Baltic	**15.68%**	**ARAG**	**12.96%**
Black Sea	**11.48%**	**Baltic**	**12.67%**
ARAG	10.78%	Black Sea	7.72%
Southeast Asia	6.49%	East Mediterranean	7.19%
North Continent	5.12%	Southeast Asia	6.33%
East Mediterranean	4.97%	West Mediterranean	4.70%
West Mediterranean	3.94%	North Continent	3.58%
Spain Atlantic	3.57%	UK - Ireland	3.13%
United Kingdom Ireland	2.40%	Spain Atlantic	2.49%
Others	9.64%	Others	14.86%
	100%		100%

From the data retrieved for this study, the Minibulk carriers in the Far East primarily loaded steel for transport within the zone, i.e. China to China. Other commodities loaded include coal, cement, aggregates, and grain (Figure 23), the probability of employment averaged at 50%. For Minibulks in the Black Sea zone (Figure 24), it also traded intrazonal between surrounding countries of Denmark, Estonia, Finland, Latvia, Lithuania, Sweden, northeast Germany, Poland, and Russia, with a 50% probability of employment.

Figure 23. Probability of employment in Far East (Minibulk)

Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis

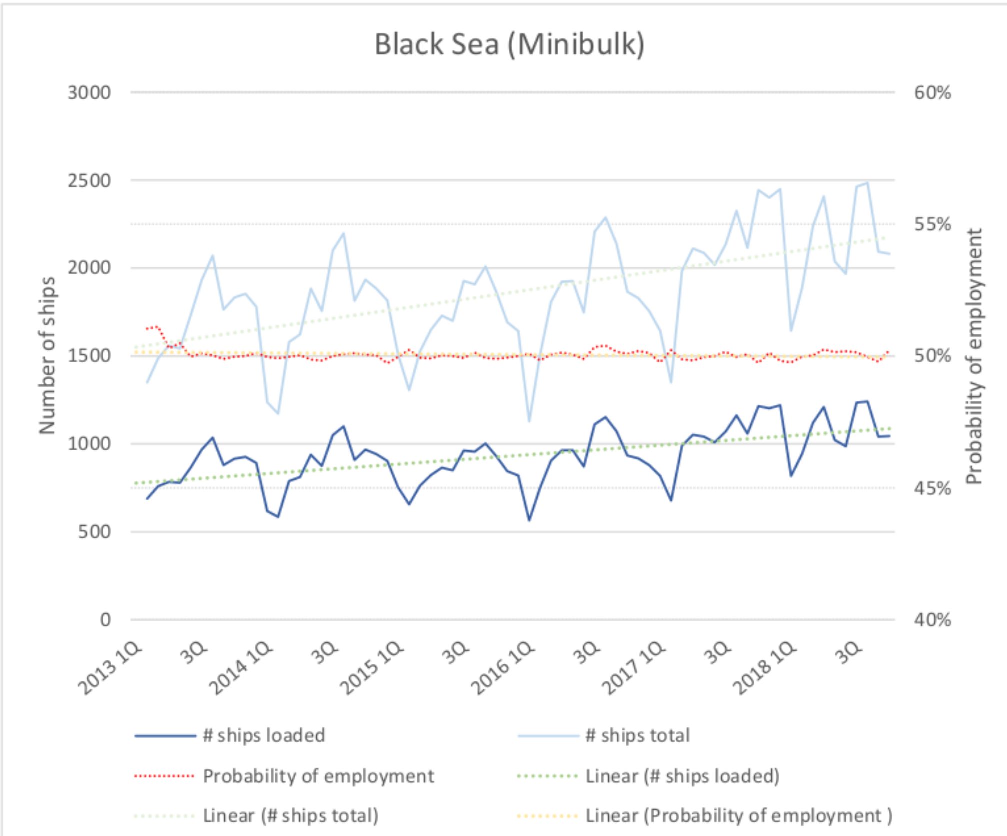
Figure 24. Probability of employment in Baltic (Minibulk)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis

The seasonal fluctuation of transport demand and ship supply in the Black Sea zone of the Minibulk segment (Figure 25) is primarily due to the cargo transported. Load record consists mainly of agricultural products such as barley, grain, flour, and bulk fertilizers between Russia, Turkey, Ukraine, Romania, Bulgaria, Moldova, and Georgia. Probability of employment in the zone averaged at 50%.

Figure 25. Probability of employment in Black Sea (Minibulk)



Note: The figure displays the total number of ships in the zone from 2013 to 2018, as well as the number of ships chartered and loaded in the same period. The probability of employment (%) for that zone is displayed in the secondary axis

Table 20. Load zone to discharge zone mapping (Minibulk)

LOAD ZONE	**Far East**		**Baltic**		**Black Sea**	
DISCH ZONE	# activity	Disch %	# activity	Disch %	# activity	Disch %
[Unknown]	0	0.00%	0	0.00%	1	0.00%
ARAG	88	0.06%	24385	27.41%	1576	2.50%
Baltic	31	0.02%	48908	54.97%	210	0.33%
Black Sea	47	0.03%	240	0.27%	37497	59.57%
Caribbean	16	0.01%	27	0.03%	3	0.00%
Caspian Sea	1	0.00%	5	0.01%	334	0.53%
East Africa	32	0.02%	28	0.03%	15	0.02%
East Australia	124	0.08%	9	0.01%	2	0.00%
East Coast Canada	7	0.00%	39	0.04%	6	0.01%
ECCA	40	0.03%	5	0.01%	6	0.01%
East Coast India	634	0.42%	28	0.03%	23	0.04%
ECSA	118	0.08%	52	0.06%	17	0.03%
East Coast U.S	68	0.05%	264	0.30%	5	0.01%
East Mediterranean	60	0.04%	751	0.84%	20818	33.07%
Far East	135453	90.61%	62	0.07%	42	0.07%
French Atlantic	2	0.00%	721	0.81%	270	0.43%
Great Lakes	17	0.01%	112	0.13%	7	0.01%
Indian Ocean	10	0.01%	0	0.00%	1	0.00%
Mid Pacific	46	0.03%	0	0.00%	0	0.00%
Mid-North Atlantic	0	0.00%	12	0.01%	9	0.01%
New Zealand	26	0.02%	1	0.00%	0	0.00%
North Pacific	75	0.05%	4	0.00%	3	0.00%
NCSA	30	0.02%	57	0.06%	6	0.01%
North Continent	34	0.02%	5780	6.50%	39	0.06%
North East Passage	29	0.02%	0	0.00%	0	0.00%
North West Africa	27	0.02%	702	0.79%	537	0.85%
North West Passage	0	0.00%	0	0.00%	0	0.00%
Persian Gulf	339	0.23%	30	0.03%	91	0.14%
Red Sea	103	0.07%	33	0.04%	154	0.24%
Saint Lawrence	27	0.02%	73	0.08%	8	0.01%
South Africa	10	0.01%	4	0.00%	6	0.01%
South Atlantic	0	0.00%	0	0.00%	0	0.00%
Southeast Asia	11891	7.95%	20	0.02%	25	0.04%
South Pacific	7	0.00%	1	0.00%	0	0.00%
South West Africa	77	0.05%	228	0.26%	123	0.20%
Spain Atlantic	10	0.01%	2430	2.73%	695	1.10%
UK - Ireland	17	0.01%	3955	4.45%	418	0.66%
US Gulf	112	0.07%	105	0.12%	25	0.04%
West Australia	157	0.11%	3	0.00%	0	0.00%
WCCA	44	0.03%	20	0.02%	1	0.00%
West Coast India	229	0.15%	20	0.02%	23	0.04%
WCSA	44	0.03%	13	0.01%	8	0.01%
West Mediterranean	39	0.03%	1639	1.84%	3549	5.64%

Note: The table maps the distribution sequence of the top three load zones by identifying the top three discharge zones for each.

As earlier mentioned, Minibulk specializes in carrying smaller cargo quantity on shorter routes, smaller ports, and shallower waters inaccessible to its bigger bulk carrier counterparts. This is evident when observing the load-discharge mapping of Minibulks in Table 20 where the load zone is primarily also the discharge zone or to the next nearby zone, i.e., 90.61% Far East-Far East, 54.97% Baltic-Baltic, 27.41% Baltic-ARAG, 59.57% Black Sea-Black Sea, and 33.07% Black Sea-East Mediterranean. With the Minibulk segment being mostly intrazonal, the load-discharge mapping better suited for this segment is by load country or load port to better identify optimal routing and scheduling.

Chapter 5. Conclusion

This dissertation has provided a matrix containing actual trade activity of the different bulk carrier segments in its respective geographic zone from 2013 to 2018 and determined the probability of employment for each. A review of recent publications that study the current state and trends of tramp ship routing and scheduling problems found that there is an underlying risk of developing impractical solutions to real-world optimization problems since current processes use randomly generated artificial data that attributed to the lack of real-life data. Having obtained actual trade data for the period 2013-2018, the initial objective of the research work was to determine the effects on freight rate by the ratio of demand to supply from the perspective of ships' geographical distribution. Due to time constraints, this research does not include further statistical data to determine such and can be a direction for continued research. Nonetheless, this dissertation carried out gathering and organizing data to form a matrix and then assessing that matrix to determine the probability of employment for each bulk carrier segment in its respective geographic trade zone as well as percentages for its next zone destination. However, identifying the geographical distribution of ships by its trade zone alone for the researched period is insufficient in determining a pattern for an optimized trade route as planning can still be narrowed down to load countries and load ports. In addition, uncertainty plays a critical role in fleet optimization due to a continually changing and competitive environment with many unforeseen events and large daily variations in demand, compounded by the development of adverse sea and weather conditions that impact sailing plans. Also, discharge ports in tramp shipping can be unknown even during loading, as well as unexpected delays during port operations due to strikes and lack of berth availability. An important area for further research is the development of methods and processes for TSRSP that will use the actual trade data presented in this study to determine fleet planning and scheduling optimization for tramp ship bulk carrier owners and operators.

Chapter 5.1. Limitations

This dissertation is limited to the distribution of dry bulk tramp ships by geographic zone from 2013-2018 with a general overview of the market assessment during the period.

Chapter 5.2. Scope for Future Studies

As mentioned above, a scope for further research is determining the effects on freight rate by the geographic distribution of tramp ships. Another is the use of actual trade data to model processes and solutions for TSRSP. Lastly, an interesting scope for future study is the effect of the recent COVID19 pandemic to the geographical distribution and employment probability of the different bulk carrier tramp ships when more recent trade data is obtained.

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